PARTIAL REPLACEMENT OF RECYCLED AGGREGATE WITH COARSE AGGREGATE

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DEPARTMENT OF STRUCTURAL ENGINEERING

FACULTY OF ENGINEERING

UNIVERSITY OF BENIN

BENIN CITY

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CERTIFICATION

This project with the Title building construction waste management within the University of Benin by IGHORODGE TEGA CHRISTIAN with Matriculation Number: ENG1708896 have satisfied the regulations governing the award of bachelor's degree in Structural Engineering in University of Benin, Benin City, Edo State. Nigeria.

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DEDICATION

I dedicate this work to Almighty God, my parents MR AND MRS IGHORODGE, who stood by me in time of trials and challenges I encountered during the work.

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ABSTRACT

This project is aim at developing high strength concrete from recycled aggregates, with the specific objectives determine the benefit / cost ratio in the development of high strength concrete from recycled aggregates, determine the compressive strength of the blended concrete when waste concrete is recycled, help control environmental pollution, waste concrete is beneficial and necessary from the viewpoint of environmental preservation and effective utilization of resources, determining the design of experiment of the blended concrete.

The results of the project were generated by applying different scope such as specific gravity, Particular size distribution, slump test of fresh concrete, flexural and compressive strength. The compressive strength for 5% 10%, 15% and 20% replacement of coarse aggregate by waste coarse concrete were compared with conventional/natural concrete.

It is seen from the figure above that the compressive strength of the cube increases on 5%, 10%, replacement and reduces on further increase in 15%, 20% and 25% recycled crushed coarse aggregates.

Tests conducted on demolished coarse aggregates and results compared with natural coarse aggregates are satisfactory as BS Standard, the test results of compressive strength shows that the optimum replacement of fine aggregate is achieved at 10% replacement of fine aggregate by demolished concrete waste compared to the respective conventional concrete strength, the possibility exists for the partial replacement of fine aggregate with demolished concrete waste which is produced during demolition of construction site.

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CHAPTER ONE

INTERODUCTION

1.1 Background to the study

Lack of natural resources, such as river sand, which in some locations is a significant problem for Nigeria's construction industry. Because of this, it is our duty to maintain natural resources like sand and stones. Some of the natural elements used in concrete can be replaced in part with recycled aggregates. To create recycled aggregates, inorganic debris from construction and demolition is crushed and graded (Manish and Dilip 2014). Recycling concrete scraps is a rather simple procedure. In order to manufacture a material of a specific size and quality, existing concrete must be broken, removed, and crushed.. Vijai and Kumutha (2010).

Cement, water, coarse and fine sand, and other ingredients are mixed in various ratios to produce concrete of varying strengths.Animesh and others (2017). Significant volumes of construction and demolition waste are created worldwide, not only in Nigeria. The majority of these wastes mainly increase yearly. An estimated 11 billion metric tons of concrete are produced each year, with fine aggregate (mostly formed of natural rock) making up 70–75% of that total, water making up 15%, and cementing agents making up 10%–15%. To address the growing environmental need to reduce solid waste and recycle as much as possible, the concrete industry has put in place a number of measures, including using a variety of waste materials in place of fine aggregate and coarse aggregate. Animesh et al., 2013, and Sharifi et al (2017). Notably, the need for fine aggregate is extremely high in the modern world, which is always focusing on building bigger and better infrastructure.

The current resource shortage of river sand, for example, poses a significant challenge for the Nigerian building industry in some locations due to the growing exploitation of natural resources.

The problem is that because we are constantly depleting natural resources, an ecological imbalance is being caused by the increased use of natural fine aggregate. The building sector must therefore partially replace fine aggregate. Researchers and scientists are working on robot silica or sand, brick debris, filtered sand, treated and sieved silt removed from dams and reservoirs, treated and manufactured sand, as well as other recent innovations to reduce or completely replace the use of fine aggregate. These alternatives to natural sand include sand from other water bodies. Building debris can be used as fine aggregate as an alternative to quarrying and replenishing rivers with sand.

The current study provides a summary of past initiatives to replace fine aggregate as well as an assessment of the usefulness of crushed brick as a partial replacement for sand in concrete. Additionally, the performance of the replacement concrete material is compared to that of traditional concrete. This effort also advances our knowledge of how bricks could strengthen structures. Significant volumes of construction and demolition waste are created worldwide, not only in Nigeria. The majority of these wastes mainly increase yearly. Recycling construction waste is becoming increasingly significant in the industry since it protects natural resources and reduces environmental pollution by eliminating the need to dump it in landfills and instead using it as a source of aggregate to create fresh concrete.. Akmal and Sami (2009).

Construction's raw materials must be used carefully because they are typically naturally occurring and a limited resource. Pathak and Yadav (2009). It is required to remove imbedded parts like plastic, steel, lumber, dirt, steel, roofing materials, and cladding materials. Dilip and Manish (2014). Recycled aggregates, which also include the original particles, have a lower specific

gravity and a larger porosity when compared to equivalent natural aggregates Manish and Dilip

(2014). Increased porosity in recycled concrete aggregate increases absorption, according to Limbachiya et al (2000). Padmini et al. discovered that the quality of the recycled material used has a substantial impact on the quality of the concrete manufactured using recycled aggregate. In recycled concrete, RCA and RFA are used to partially replace NCA and NFA (2009).

1.2 STATEMENT OF THE PROBLEM

Due to the main increase in concrete rubbish, these wastes are generally increasing each year. Concrete debris can be used as a source of aggregate for creating new concrete, protecting natural resources while also reducing environmental pollution by eliminating the need to dump it in landfills.

1.3 AIM AND OBJECTIVES

The aim is to develop high strength concrete from recycled aggregates The specific objectives include

i. determine the benefit / cost ratio in the development of high strength concrete from recycled aggregates.

ii. determine the compressive strength of the blended concrete when waste concrete is recycled

iii. help control environmental pollution

iv. waste concrete is beneficial and necessary from the viewpoint of environmental preservation and effective utilization of resources.

v. determining the design of experiment of the blended concrete

1.4 SCOPE WORK

The Scope of The Work Includes

A. GEOGRAPHICAL PROPERTIES OF WASTE RECYCLED COARSED AGGREGATE

i. Specific gravity of the recycled concrete

ii. Bulk Density Test of the Concrete

iii. Water absorption

iv. Particle size distribution of both the fine, coarse aggregates and the waste concrete used in the experiment.

B. COMPRESSIVE STRENGTH OF CEMENT – WASTE RECYCLED COARSED AGGREGATE IN CONCRETE PRODUCTION USING COMPRESSION MACHINE.

v. The workability of the blended concrete

vi. Compressive strength of concrete

1.5 JUSTIFICATION OF THE STUDY

The study's findings will inform the general public and those working in the construction business about the creation of high-strength concrete using recycled aggregates.

It will also create awareness in the construction industry.

CHAPTER TWO

2.0 LITERATURE REVIEW

According to the CMBUREAU (2008) Mehta, estimate, the global use of concrete is two and a half tons per person per year, or 17.5 billion tons (2009).To create this enormous volume of concrete 13.12 billion tons of aggregate, 2.62 billion tons of cement, and 1.75 billion tons of water are needed. Typically, aggregates are obtained by breaking clay bricks, mountainous terrain, river gravel or boulders, or mountainous terrain. Many natural resources can be saved if the concrete from demolished buildings is recycled for new construction. In addition to protecting natural resources, recycling demolished concrete will also benefit local governments by helping them achieve their aim of minimizing disposal, creating new business opportunities, cutting disposal costs, saving money for local governments and other customers, etc.

Currently, 2 to 3 billion tons of concrete have been destroyed globally, according to Torring and Lauritzen (2002). For the construction of roads, 60 to 70 percent of demolished concrete is used as sub-base aggregate Yanagibashi et al (2002). Concrete that has been demolished can be recycled, saving 20% of usual aggregates. Additionally, according to Torring and LauritzenOver the next ten years, there will be an increase in the amount of concrete that is destroyed to 7.5-12.5 billion tons (2002). If recycled aggregate technology and public approval of its use are perfected, new construction won't need any conventional aggregate if demolished concrete is recycled entirely.

The amount of demolished concrete in Bangladesh is increasing as a result of the deterioration of concrete structures and the replacement of numerous low-rise buildings with relatively high-rise structures as a result of the booming real estate business. Building developers are growing more and more concerned about what to do with the concrete that has been removed from the site. If the demolished concrete is used in new construction, the disposal issue will be solved, the need for new aggregates will drop, and ultimately, fewer natural resources will be used to generate aggregate. On other project sites, it was also determined that some of the demolished concrete was repurposed as aggregate in foundation works without any research into the recycled materials. In older buildings, brick chips were often used as the coarse aggregate. For stone chips produced concrete, studies on the recycling of demolished concrete are typically found. Zega et al, (2010), Kou et al, (2011).

Montgomery reports a reduction in the concrete's compressive strength of 17% at a replacement ratio of 33%. In comparison to natural aggregate, recycled aggregate in concrete had a compressive strength that was 18.76% lower. Compared to the recycled aggregate, the water-treated version has increased nitric acid by 11.88%, sulphuric acid by 5.38%, hydrochloric acid by 7.17%, and sulfuric acid by 4.93%.In comparison to natural aggregate, recycled aggregate in concrete had a compressive strength that was 18.76% lower. Compared to the recycled aggregate, the water- treated version has increased nitric acid by 11.88%, sulphuric acid by 5.38%, hydrochloric acid by 7.17%, and sulfuric acid by 4.93%.G. Murali et al.).

Investigations on the recycling of demolished concrete are therefore required. Concrete is a composite material primarily made of cement, water, and aggregate. To give the completed material the desired physical and mechanical qualities, additives and reinforcements are frequently added to the mixture. The two main materials needed to make concrete are cement and aggregate (river sand and crushed stone). Investigations on the recycling of demolished concrete are therefore required. Concrete is a composite material composed mainly of water aggregate and cement. Often, additives and reinforcements are included in the mixture to achieve the desired physical and mechanical properties of the finished material. Cement and aggregate (river sand and crushed stone), are the most important constituents used in concrete production. Investigations on the recycling of demolished concrete are therefore required. Concrete is a composite material primarily made of cement, water, and aggregate. Additives and reinforcements are typically incorporated into the mixture to give the finished product the desired physical and mechanical properties. Cement and aggregate are the two primary components required to build concrete (river sand and crushed stone). Therefore, research into the recycling of demolished concrete is needed. Cement, water, and aggregate are the main components of the composite material known as concrete. Additives and reinforcements are typically incorporated into the mixture to give the finished product the desired physical and mechanical properties. Cement and aggregate are the two primary components required to build concrete (river sand and crushed stone).

Naturally, this leads to a persistent and rising demand for the natural resources used to make concrete. In addition to the obligation to use natural resources, there is a growing need to preserve natural resources like aggregate by using substitute materials that are either recycled or thrown away as trash. Naturally, this leads to a persistent and rising demand for the natural resources used to make concrete. In addition to the obligation to use natural resources, there is a growing need to preserve natural resources like aggregate by using substitute materials that are either recycled or thrown away as trash. Ceramic is widely used to make bricks, roofing tiles, wall and floor tiles, and other building materials. Sanitary ceramics are created from natural materials including kaolin, china clay, feldspar, potassium, and quartz, much like all other ceramic products. (Pacheco and Jalali, 2010). Ceramics industry includes the following sectors: ceramic flooring and wall coverings (ceramic floor and wall tiles, respectively), ceramic sanitary ware, bricks and roofing tiles, refractory materials, ceramics for technological applications (insulators, etc.), and ceramic objects for domestic and decorative purposes (tableware and ornaments). Ceramic floor and wall tiles, ceramic sanitary ware, bricks and roofing tiles, refractory materials, ceramics for technological applications (insulators, etc.), and ceramic objects for residential and ornamental reasons are all included in the ceramics industry (tableware and ornaments).

The majority of ceramic materials are consumed by the building sector, which is well-positioned to address this partly self-created environmental problem. Akash Rao and others (2007). Conclusion: The management of C and D trash can be improved with the use of recycled aggregate in concrete. The majority of the world's solid waste production is made up of construction and demolition (C and D) trash, which is disposed of in landfills. Concrete engineers' research has been quite supportive of the idea of correctly treating and reusing such waste as aggregate in new concrete, especially in lower-level applications.

It is clear that RAC can be used in lower-end applications of concrete based on a review of production, the use of RA in RAC, and the features of RA and RAC. With specific pilot studies, RA can be utilized to produce regular structural concrete with the addition of fly ash, condensed silica fume, etc. The goal of Sudhir P. Patil et al(2013) .'s study on recycled coarse aggregate is to evaluate the physical characteristics of concrete constructed with recycled coarse aggregate. A demolished building near Kamla Nehru Park on Bhandarkar Road in Pune has been utilized to gather research concrete debris, which is then combined with various percentages of coarse aggregate to create new concrete. Many experts believe that recycled aggregate should only be used in non-structural concrete applications. This study shows that high-quality concrete can still be made utilizing recycled materials derived from concrete specimens. The compressive strength of concrete that contains 50% RCA is comparable to that of typical concrete.

Concrete has good tensile strength when replaced up to 25–50%, according to tensile splitting tests. Concrete's strength is high in the beginning but steadily declines as it ages. RCA absorbs more water than natural aggregate. In conclusion, it can be claimed that the RCA up to 50% can be used to produce concrete of high quality. For more than a century, concrete has been proven to be a top building material. In addition to being cost-effective, using waste materials in concrete helps with some of the problems associated with trash disposal. Concrete made from crushed ceramic aggregate can be made lighter without losing strength. Senthamarai et al., (2005). Due to the construction industry's high raw material consumption, there is a persistent shortage of building supplies, which has an adverse effect on the environment. Numerous studies on the use of waste materials in concrete have been undertaken in the last ten years in the building sector in an effort to use less natural resources.

Khaloo, (1995) The use of crushed tile as a source for coarse aggregate in concrete was researched. In comparison to naturally occurring crushed stones, the crushed tile had a lower density and a substantially higher water absorption value. With 100% crushed tile as the coarse aggregate, the resulting concrete had a reduced density and higher compressive (+2%), tensile (+70%), and flexural (+29%) strengths. D. Tavakoli, (2012) Concrete's characteristics are not noticeably harmed by using ceramic waste in the manufacturing of concrete. In addition, the best case scenario for using tile waste as coarse aggregate is in proportions of 10% to 20%. The ideal case scenario for using tile waste as sand is 25% to 50%. These measurements show not just a gain in compressive strength but also a reduction in unit weight and no discernible adverse impact on water absorption. However, the few studies that have been done thus far on the subject of incorporating ceramic wastes in concrete do not completely assess the new concrete's mechanical qualities, which are crucial. Therefore, this is a study field that has to be thoroughly examined.

According to the findings mentioned above, it is imperative that recycled ceramic aggregates be used in concrete bins in an environmentally acceptable manner.

The purpose of the study is to investigate the "Effects of Replacing Partially Coarse Aggregate with Broken Ceramic Tiles in Concrete Production," with the goals being to identify the physical characteristics of the aggregates to be used, assess the workability of fresh concrete using the slump test and compacting factor test, and cure hardened concrete for 7, 21, and 28 days before determining their mechanical properties. This study will make significant progress toward lowering the high consumption of natural resources (crushed granite) required to make concrete, which, in turn, will lower the risks to the environment and people posed by granite crushing. On the other hand, replacing some of the coarse aggregate with ceramic waste will minimize the amount of solid waste produced by the ceramic industry that needs to be disposed of as well as the expense of disposal. Additionally, the cost of producing concrete will drop significantly.

According to a 1999 report given to the European Commission, there are 1.3 billion t of non-recycled building waste produced year. This amount of waste requires enough space to fill a pile that would be 1.3 meters high and cover all of central Paris .Globally, 9.3 billion t/year of coarse aggregate are thought to be needed to make concrete. In the next ten years, there will likely be 3 to 5 times as much concrete destroyed as there is now, which is roughly 7.5 to 12.5 billion tons. Therefore, there won't be much demand for virgin aggregate in the near future if recycled concrete is used as coarse aggregate in new building. The literature has described a number of ways to enhance the qualities of new concrete created from recycled aggregate. Sri Ravindrarajah and Tam, (1988) improved the properties of new concrete by altering the water/cement ratio, adding pozzolans, and blending recycled and natural aggregates.

These methods, however, do not directly address how to improve recycled aggregate; rather, they speak to basic concrete technology. Montgomery, (1998) treated the aggregate with a ball mill in order to remove old cement paste from natural stone. He found that the cleaner the aggregate was, the stronger was the concrete. Winkler and Mueller, (1998) and Montgomery, (1998) milled recycled fines and used.

The purpose of the current study is to compare the compressive strength of concrete made with recycled coarse aggregate and concrete made with conventional aggregate, such as stone chips, in order to determine the strength of concrete made with recycled coarse aggregate depending on the various contents of recycled coarse aggregate.

concrete that has been destroyed was made by crushing samples of old laboratory concrete with a 3000-psi compressive strength. The aggregates' abrasion, unit weight, and absorption capacities were examined prior to the creation of concrete. Aggregate grading followed a set standard. Concrete cylinder specimens with dimensions of 150 mm in diameter and 300 mm in height were created and evaluated for compressive strength. In addition, recycled aggregate was used as much as possible in place of conventional aggregate to achieve acceptable concrete quality and lower the cost of building a new concrete structure.

Civil engineering directly affects the design and construction of many constructions. Any structure must be built with building supplies including sand, stones, bricks, cement, concrete, steel, glass, and other materials. For sustainable development, which involves employing renewable resources to preserve natural resources and reduce environmental contamination, there is a significant demand for these materials in the building sector. Reusing and recycling trash from the site of demolished buildings is necessary in light of this. Many academics and researchers have recently neglected to look for a replacement for natural fine aggregate and coarse aggregate.

Different materials have been tried already such as glass waste, wooden waste, plastic, and other waste materials. Gamashta and Gumashta, (2006) experimented by using concrete and masonry waste material to check different properties and suggested some useful comments for further research and enhancement of the life of the structure considering the cost of the structure to be economical. Lakshmi and Nivedhitha, (2015) did experiments and investigated the changes in compressive strength, flexural strength and tensile strength by replacing the natural fine aggregate and natural coarse aggregate with the recycled fine and coarse aggregate.

Recycled fine and coarse aggregate was used to replace various percentages of natural fine aggregate and coarse aggregate, including 10%, 20%, and 30%. On the concrete, tests were conducted, and the outcomes were compared. They discovered that substituting recycled material for fine and coarse aggregate raised the compressive and tensile strength by 20%. And as the amount of natural fine aggregate and coarse aggregate replacement increased, the flexural strength decreased. Nili et al., (2012) made research on the use of waste materials in concrete as partial replacements for aggregates and even cement, perhaps as an environmentally acceptable building material. Waste glass of all kinds, mostly container glass, thin film transistor liquid crystal display (TFT-LCD), crushed clay brick aggregate, polyethylene (PET), scraped PVC pipes, rubbers of various types, recycled ceramic materials from sanitary installation, and recycling ornamental stones are the six types of waste materials. (Granite and Marble).

To assess their utilization and significance in the concrete and mortar, several parameters for each category of recycled materials were documented. This has been considered, and the material should be both affordable and environmentally benign. By using blast furnace slag from the iron ore industries in place of the aggregate, Sriharsha and Murthy (2014) conducted research on several samples. On the concrete's mechanical and physical characteristics, many tests were conducted. Strength at various replacements was measured and contrasted with various concrete mixes. The utilization of demolition trash, such as ceramic tiles and broken bricks, as a partial replacement for natural coarse aggregate in concrete was the topic of Kumar and Siva's (2015) study. The finished concrete was put through a variety of tests, including workability and compressive strength tests, and it was compared to normal concrete. Although the concrete loses part of its workability, its increased strength and light weight are still clearly visible. In order to help with environmental issues and solid waste management, it is effectively explored and used to find a partial replacement for sand with demolition trash as an aggregate without changing the qualities of traditional concrete. Kumar et al., (2016) in this research replaced the natural fine aggregate (sand) partially with the coal bottom ash by different percentages 10, 20, 30, 40, and 50%. The grade of concrete was M25 and different properties were studied. Bottom ash forms 25% of the total ash and the remaining 75% is formed by fly ash.

Because bottom ash was used in place of fine aggregate, the workability of the concrete was somewhat diminished. As a result, it was determined that coal bottom ash could substitute some of the fine aggregate in concrete up to a maximum of 15 to 20 percent by weight of the aggregate. In order to explore the various properties of concrete, Samanth and Prakhar (2016) substituted recycled and demolition rubble for coarse and fine aggregate. The test was run to investigate the properties of concrete made without cement. So that this trash can be used without harming the environment.

Utilizing recycled aggregate is unquestionably a crucial step toward the management of building waste and sustainable development in the concrete industry. Natural aggregate can be replaced with recycled aggregate (RA), which benefits environmental preservation. Variability in the qualities of the recycled aggregate is one of the important factors that influence its utilization. The quality of the materials collected and transported to the recycling plants has an impact on the quality of the recycled aggregate. Due to the present restrictions on the recycling plants, it is difficult to produce recycled aggregate at an acceptable price rate and quality. The stability of output and unpredictability in aggregate qualities are issues that worry the clients.

Investigating the diversity of aggregate qualities and how it affects concrete production is the main objective of the current research project. Some of the physical and mechanical qualities of aggregates, such as their strength, gradation, absorption, moisture content, specific gravity, form, and texture, help to make concrete strong and long-lasting. As a result, before using the aggregate, these qualities must be assessed. This study assessed the characteristics of recycled aggregate from an unidentified source that was collected over the course of six months from a recycling facility. Additionally, the characteristics of concrete made entirely from recycled aggregates were examined.

The building industry's development raises various questions about the availability of natural aggregate resources because they are quickly running out. According to recent figures, the demand for construction aggregate would increase and reach 48.3 billion metric tons by the year 2015, with Asia and the Pacific having the biggest consumption. (2012). This increasing demand is accompanied by an increase of construction waste. For example, construction waste from European Union countries represents about 31 % of the total waste generation per year Marinkovic et al., (2010), Ministry of Natural Resources, (2010). Similarly, in Hong Kong, the waste production was nearly 20 million tons in the year 2011, which constitutes about 50 % of the global waste generation Tam and Tam (2007), Lu and Tam (2013), Ann et al., (2013).

Disposal in landfills is the common method to manage the construction waste, which creates large deposits of construction and demolition waste sites Marinkovic et al., (2010), Tam and Tam (2007), Naik and Moriconi, (2005). Efforts to limit this practice and to encourage recycling of construction and demolition waste in different construction applications led to utilizing up to 10% of the recycled aggregate in different construction applications Marinkovic et al., (2010), Ministry of Natural Resources, (2010), Naik and Moriconi (2005), European Aggregate Association, (2010), Cement, Concrete, and Aggregates (2008), Tepordei, (1999). Therefore, recycling has the potential to reduce the amount of waste materials disposed of in landfills and to preserve natural resources Sonawane and Pimplikar, (2013), Llatas, (2011), Lu and Yuan, (2011), Braunschweig et al., (2011), Marinkovic et al., (2010), Gupta, (2009), Rao et al., (2010), Tam, (2008), Topcu and Guncan (1995).

The objectives of policies, cost, and benefits are to highlight the costs of capital investments, standardize the use of RA in concrete, and stress the positive effects on the environment and economy. The main advantages of using recycled materials in the construction sector are land protection and resource preservation Hansen., (1986), Kartam et al., (2004), FHWA, (2004), Oikonomou, (2005), Tam and Tam, (2007), EU Directive 2008/98/EC, Ministry of Natural Resources, (2010), Marinkovic et al., (2010), Ann et al., (2013), Silva et al., (2014), Lu and Tam, (2013), Bodet, (2014).

The main factors that influence using RA in concrete production are its evaluation of its physical and mechanical properties, absorption, aggregate texture (type of crushers, number of crushing stages), aggregate size and gradation, specific gravity, density, mortar content, percentage and type of contamination, aggregate strength, and abrasion resistance. The properties of concrete made with RA can vary due to loading, different environmental factors, the crushing process, contamination, and impurities like wood and plastic fragments.

Mortar adhered to RA lead to lower density, high absorption, and high L.A. abrasion loss. In addition, sulphate and alkali contents cause expansive reactions which can be controlled if the maximum sulphate is in the range of 0.8–1.0 % by mass and alkali content below 3.5 kg/m3 Tam et al., (2008), De Juan and Gutie´rrez, (2009), McNeil and Kang, (2013), De Brito and Saikia, (2013), Akbarnezhad et al., (2013), Silva et al., (2014). Mix design and proportioning: direct volume replacement, weight replacement and equivalent mortar replacement are some of the approaches that could be followed to design mixtures with RA. In addition, the mixing process can affect overall concrete properties.

Both volume replacements and pre-soaking approaches showed improved properties of concrete produced with RA Tam et al., (2007a, b), Cabral et al., (2010), Fathifazl et al., (2009), Knaack and Kurama, (2013), Wardeh et al., (2014). There have been many attempts to assess the qualities of RA-made concrete when it is fresh and when it has hardened. Investigations were also conducted to optimize the amount of RA that may be employed without degrading both short- and long-term performance. Additionally, design equations based on information gathered from numerous sources were put out. Due to its high porosity and high absorption, recycled aggregate generally resulted in a reduction in all mechanical properties, as well as fresh stage qualities and concrete durability. Xiao et al., (2006), Yang et al., (2008), Kwan et al., (2012), Manzi et al., (2013), Akbarnezhad et al., (2013), Ulloa et al., (2013), Xiao et al. (2014), McNeil and Kang, (2013), Silva et al., (2014).

Enhancing the durability of RA concrete: One barrier preventing the use of RA in many applications is worries about the durability and long-term performance of concrete containing RA. Some of the parameters that could be used as durability and long-term performance indicators for concrete include chloride conductivity, oxygen and water permeability, carbonation depth, alkaline aggregate reaction, sulphate resistance, shrinkage and creep performance, abrasion resistance, and freeze resistance. Due to the increased pore volume, which resulted in high permeability and water absorption, RA-made concrete often demonstrated inferior durability. Due to cement paste being stuck to the aggregate surface, there is high water absorption.

By obtaining saturated surface dry (SSD) conditions prior to mixing, this can be avoided. In some instances of mass production, this might not be practical. Therefore, by changing the mixing water that will be absorbed by the recycled aggregate, aggregate absorption can be taken into account during the mix design stage.

Additionally, numerous studies have demonstrated that adding supplementary cementitious materials (SCM) in place of cement or in addition to it might increase the durability of concrete by enhancing pore structure and decreasing the amount of macropores. The most frequently used SCM for enhancing concrete's strength and durability are ground-granulated blast-furnace slag (up to 65%), fly ash (25–35%), and silica fume (10%). (Berndt Demand on construction aggregates worldwide The Freedonia Group, (2012).

Microstructure, interfacial transition zone (ITZ), and bond characteristics: A careful examination of the ITZ revealed a porous microstructure, which can be attributed to the recycled aggregate's high porosity and high absorption capacity. Additionally, fissures in concrete and a weakening of the link between the cement and aggregate may result from processing, crushing, exposure to chemicals, and deposition of toxic compounds on aggregate surfaces Microstructure, interfacial transition zone (ITZ), and bond characteristics: A careful examination of the ITZ revealed a porous microstructure, which can be attributed to the recycled aggregate's high porosity and high absorption capacity. Additionally, fissures in concrete and a weakening of the link between the cement and aggregate may result from processing, crushing, exposure to chemicals, and deposition of toxic compounds on aggregate surfaces.

The mixing process, less w/c ratio and addition of SCM can improve the ITZ and bond characteristics of recycled aggregate concrete Otsuki et al., (2003), Poon et al., (2004), Tam et al., (2005), Evangelista and Brito, (2007), Tabsh and Abdelfatah, (2009), Xiao et al., (2012a). Aggregates Used in the Study Quality and availability of recycled aggregate are the main factors towards stable use and introduction of recycled aggregate concrete to the construction industry.

CHAPTER THREE

3.0 METHODOLOGY

3.1 MATERIALS

3.1.1 Test on Cement

The cement utilized in this experiment was Portland cement of grade 43N, according to BS. The cement came from a single shipment, was the same grade, and came from the same source. producing the cement and ensuring correct storage of it.

3.2 FINE AGGREGATE

The British Standard is the code to which the specification for fine aggregates should be referred. As fine aggregate, sand with a particle size less than 4.75 mm was employed. The fine aggregate's specific gravity and fineness modulus were 2.65 and 2.75, respectively. The river Benin is where the standard sand must be acquired, according BS. The required sand must be silt-free and of the quartz variety, in a light grey or whitish color. The sand grains must be angular and close to being spherical in shape; elongated and flattened grains must only be present in very small or negligible amounts. The standard sand must have the following particle size and pass through a 2-mm Bs sieve with 100% retention on a 90-micron Bs sieve.

Superior Aggregate River sand, a locally accessible material that complies with BS, is utilized as fine aggregate. In Zone, the sand has a specific gravity of 2.6. One percent of fine aggregate absorbs water. The crucial component of concrete is aggregate. They give concrete body, lessen shrinkage, and have an economic impact. They take up roughly 70–80% of the concrete's total volume. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or combination thereof. They shall be hard, strong, durable, clear and free from veins and adherent coating; and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky and elongated pieces should be avoided. Aggregates can be mainly classified into fine aggregates and coarse aggregates. BS STANDARD defines fine aggregates as "Aggregate most of which passes 4.75mm sieve and contains only so much coarser material as permitted." It may be:

i. Natural sand: Fine aggregate that has been deposited by streams or glaciers and is the consequence of the breakdown of rock naturally.
ii. Crushed stone sand: Crushing hard stone produces fine aggregate..
iii. Crushed gravel sand: line aggregate produced by crushing natural gravel.

Sand made from crushed stone or clay is used in this research project. For fine aggregates, there are four different grading zones: I, II, III, and IV. It is advised against using fine aggregate that complies with Grading Zone IV in reinforced concrete unless the anticipated mix proportions have been put to the test.

3.3 COARSE AGGREGATE

To understand the criteria for coarse aggregates, one should refer to the British Standard. Smaller than 20 mm hard granite broken stones were used as coarse aggregate. As a pozzolanic material, waste from demolition operations was used to partially replace coarse aggregate. Sand, gravel, or crushed stone are examples of coarse aggregates, which are granular and uneven materials used to make concrete. Coarse is typically found in nature and can be obtained by blasting quarries or crushing them manually or with crushers. The term "coarse aggregate" refers to aggregate with a size more than 4.75 mm. As coarse aggregate, crushed granite with particle sizes of 10 mm and 20mm is employed. The sieving analysis of aggregates demonstrates that they meet BS STANDARD requirements. Sand, gravel, crushed stone, and recycled concrete or fill are the four main types of aggregates. In order for the elements to come together and solidify into distinct landscaping projects like sidewalks, driveways, roadways, and parking lots, these various materials function as a holding agent. Cement, aggregates, water, and other readily accessible ingredients are mixed to create concrete. Throughout the project, ordinary Portland cement of grade 43 was employed. The clean river sand, with a maximum size of 4.75 mm, and complying to grading zone II, was the fine aggregate used in this experiment.

Concrete is made with recycled coarse aggregate that has been crushed into a coarse powder. The waste coarse aggregate, which was derived from the rubble of a demolished structure, was gathered, ground up, and retained on a 0.075 mm screen to produce the grading of fine aggregate. In the trials, fine aggregate is replaced with discarded coarse aggregate powder to a percentage of 5, 10, 15, and 20.

The aim of the experiment was to assess the properties of concrete made with crushed waste coarse aggregate and to study important aspects such as compressive strength of concrete prepared by using concrete coarse debris with different percentage of replacements with Fine Aggregate. The concrete mix design was proposed using Bs Standard for control concrete. The ratio was 1:1:2. The replacement levels of sand by waste coarse concrete powder were used in terms of 0%,5%, 10%, 15%, 20% and 25% in concrete. Cement used for the study was tested for the parameter’s specific gravity, fineness, consistency test, setting time. Fine aggregate was tested for Fineness modulus, specific gravity, Water absorption, Bulk density, Void ratio. Concrete cubes were tested for compressive strength under four different mixes. In CC mix, the conventionally Cement, Coarse aggregate, Fine Aggregate were mixed with Water and analyzed for strength parameters.

In R-1 mix only 5% Fine Aggregate is replaced with brick debris and other ingredients were as same in CC mix. In R-2 mix only 10% Fine Aggregate is replaced with waste coarse concrete debris and other ingredients were as same in CC mix. In R-3 mix only 15% Fine Aggregate is replaced with waste coarse concrete debris and other ingredients as same in CC mix. In R-4 only 20% Fine Aggregate is replaced with waste coarse concrete debris and other ingredients were as same in CC mix.

3.4 SLUMP TEST

After the mix design was prepared, measurement of materials according to the mix design and mixing of materials in the right proportion with a concrete mixer according to mix design chart followed, Slump test was carried out on the concrete using the slump apparatus to determine the slump and workability of the mix. It was carried out in accordance with BS EN 12350-2:2009.

Equipment and materials used

i. Hand trowel

ii. Concrete mixer

iii. Shovel

iv. Slump apparatus with the base and tamping rod

v. Concrete materials

vi. Measuring tape

Procedure

i. The cone's interior was oiled and cleaned.

ii. The mold was positioned on a flat, smooth base plate that was not porous.

iii. Concrete was poured into the mold in three (3) roughly equal layers.

iv. Each layer was uniformly tamped with 25 strokes of the end-rounded tamping rod over the mould's cross section, each tamping penetrating the layer underneath it.

v. The extra concrete was removed, and a trowel was used to level the surface.

vi. The mold's surrounding mortar and any water leaks were cleansed.

vii. The mould was immediately gently elevated vertically from the tamped concrete.

viii. The height of the mould was measured in comparison to the height of the tamped concrete.

Figure 1: Slump test

Sieve Analysis Test

By allowing a granular substance to pass through a number of sieve, the procedure of sieve analysis determines the particle size distribution of the substance. A nested column of wire-mesh sieves is typically used in sieve analyses. The ASTM C136 was followed in conducting this test.

Equipment Materials used

i. Testing Samples (fine and recycled aggregates)

ii. A set of sieves of known sizes with a bottom pan

iii. Mechanical shaker

iv. Weighing balance

Procedures

i. The top sieve, which has the highest screen opening, is filled with a typical weighed sample. (The lower sieve's apertures are narrower than those on the top sieve.)

ii. The pan, or receiver, was at the base.

iii. After that, the sieve column was shaken for a certain period of time.

iv. Each sieve's retention of particles was weighed.

v. To calculate the percentage retained on each sieve, the mass was divided by the total mass.

3.5 SPECIFIC GRAVITY TEST Apparatus

i. Weighing balance

ii. Oven

iii. Dry cloth(handkerchief)

iv. Shallow tray

v. watertight basket

Procedure

i. Take a representative 2 kg of the sample and wash it well to eliminate dust and smaller particles.

ii. After being washed, put the aggregates in the wire basket and submerge it in distilled water heated to around 32°C with a cover of at least 2 cm of water above the top of the basket.

iii. Immediately after the immersion, lift the basket containing the aggregates 25 mm above the bottom of the tank and let it fall per second to release any trapped air from the sample. At a drop per second, this procedure is repeated roughly 25 times.

iv. Next, remove the basket from the water and give it a few minutes to gently drain.

v. Gently pat the particles dry with a dry

Calculations

Mass of aggregates + Basket in water (M) = 2.6kg Mass of wire basket suspended in water (W) = 0.9kg

Weight (g) of saturated surface-dry aggregate in air (B) = 1800g = 1.8kg Weight of oven-dried aggregates (C) = 1.95kg

$$\text{Specific Gravity} = \frac{C}{B-(M-W)} = \frac{1.95}{1.8-(2.6-0.9)} = \frac{1.95}{1.8-1.7} = \frac{1.95}{0.1} = 19.5$$

3.6 COMPRESSION TEST

Compression test on concrete cubes

On each cube cast, the compressive test was performed (they were tested at days 3,7,14, 21 and 28). On each crushing day, three cubes were crushed for each of the six samples, and the average crushing value was noted. For a total of 28 days, 18 cubes were smashed once every seven days. According to BS 1881-116, the test was conducted.

Figure 2: Compression test

Equipment and Materials

i. 100mm by 100mm-by-100mm metallic cubes

ii. Vibrating table

iii. Concrete mixer

iv. Shovel

v. Hand trowel

vi. Head trowel

vii. Weighing balance

viii. Measuring cylinder

ix. Compression machine

x. Water

xi. Concrete materials (cement, fine and recycled aggregates)

Procedure

i. In testing for the compressive strength of the concrete cube samples, the machine was turned on and the gauges were set to zero.

ii. Thereafter, the cube samples were taken one at a time and was set at the middle of the machine, the top screw was lowered to hold the cubes in place, (the hydraulic lever was turned until it locks the cube firmly).

iii. Once this was done, the compression machine starts exerting compressive force on the cube sample, such that the cube is crushed at a particular maximum force, the dial gauge gave the maximum force reading. The crushing results are shown in the next chapter.

iv. A total of 12 cubes each were crushed on days 7, 14, 21 and 28 making a total of 12 cubes for each recycled aggregate size as shown in table 3.10.

v. Step 1-4 were conducted and the average taken as the final answer.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

TABLE 1: PROPERTIES OF CEMENT.

Properties	Observed Values
Normal consistency	28%
Initial setting time (minutes)	47min
Final setting time(minutes)	245min
3 days compressive strength	23.52 N/mm^2
7 days compressive strength	33.62 N/mm^2
28 days compressive strength	42.31 N/mm^2
Specific gravity	3.02

The results are shown below Total Mass of sand tested = 97.53g

TABLE 2: SIEVE ANALYSIS TEST RESULT FOR FINE AGGREGATE

Sieve Size (mm)	Mass Retained (g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
2.36	1.76	1.786	1.786	98.214
200	0.98	0.995	2.781	97.219
1.18	6.53	6.627	9.408	90.592
600	31.19	31.66	41.068	58.932
425	18.68	18.96	60.028	39.972
300	22.58	22.92	82.948	17.052
212	11.87	12.05	94.998	5.002
150	0.68	0.69	95.688	4.312
75	1.50	1.52	97.208	2.792
Pan	0.25	0.256	97.477	2.523

$$\% \text{ Retained} = \frac{\text{Mass retained}}{\text{Total Mass tested}} \times 100$$

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

TABLE 3:. PROPERTIES OF FINE AGGREGATE.

Properties	Observed Values
Fineness modulus	2.65
Specific gravity	2.63

The results are shown below

Result from Sieve Analysis for Crushed (Recycled) Aggregate Total Mass of sand tested = 1500g

TABLE 4: SIEVE ANALYSIS FOR CRUSHED (RECYCLED) AGGREGATE

Sieve Size (mm)	Mass Retained(g)	Percentage Retained (%)	Cumulative percentage Retained (%)	Percentage Passing (%)
20.00	6.200	0.413	0.413	99.587
10.00	460.670	30.711	31.124	68.876
8.00	781.440	52.096	83.220	16.78
6.30	102.450	6.830	90.050	9.950
5.00	86.400	5.76	94.810	5.190
3.35	63.350	4.223	99.800	0.149
Pan	3.450	0.200	100.000	2.523
Total	1500	100		

% Retained = Mass retained × 100

Total Mass tested

Cumulative % Retained = % retained + the succeeding % retained

% passing = 100−Cummulative % Retained

TABLE 5: FORMULA FOR SIEVE ANALYSIS

	Weight retained	% retained on sieve	cumulative % retained	% Finer
	W_1	$P_1 = \frac{W_1}{W} \times 100$	$C_1 = P_1$	$100 - C_1$
	W_2	$P_2 = \frac{W_2}{W} \times 100$	$C_2 = P_1 + P_2$	$100 - C_2$
	W_3	$P_3 = \frac{W_3}{W} \times 100$	$C_3 = P_1 + P_2 + P_3$	$100 - C_3$
	W_4	$P_4 = \frac{W_4}{W} \times 100$	$C_4 = P_1 + P_2 + P_3 + P_4$	$100 - C_4$
	W_5	$P_5 = \frac{W_5}{W} \times 100$	$C_5 = P_1 + P_2 + P_3 + P_4 + P_5$	$100 - C_5$
	W_{pan}	$P_{pan} = \frac{W_{pan}}{W} \times 100$	$C_{pan} = P_1 + P_2 + P_3 + P_4 + P_5 + P_{pan}$	$100 - C_{pan}$

TABLE 6: PROPERTIES OF COARSE AGGREGATE.

Properties	Observed Values
Fineness modulus	6.20
Specific gravity	2.65

TABLE 7: RESULT FOR COMPRESSION TEST FOR 0% (CONTROL) REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7 days	M1	2.462	2462	284.58	28.46	2556	29
	M2	2.440	2440	270.60	27.06		
	M3	2.468	2468	314.82	31.48		
14 days	M1	2.355	2355	345.00	34.50	2550	35.50
	M2	2.504	2504	368.25	36.83		
	M3	2.561	2561	351.75	35.18		
21 days	M1	2.514	2514	436	43.60	2553	40.00
	M2	2.577	2577	386	38.60		
	M3	2.568	2568	378	37.80		
28 days	M1	2.565	2565	415.23	41.52	2532	42.60
	M2	2.531	2531	423.87	42.39		
	M3	2.501	2501	438.90	43.89		

TABLE 8: RESULT FOR COMPRESSION TEST FOR 5% REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7 days	M1	2.511	2511	289.00	28.90	2539.667	31.2
	M2	2.539	2539	328.77	32.88		
	M3	2.569	2569	318.23	31.82		
14 days	M1	2.557	2557	365.00	36.50	2630.000	37.20
	M2	2.770	2770	384.00	38.40		
	M3	2.563	2563	367.00	36.70		
21 days	M1	2.468	2468	368.26	36.83	2538.333	41.10
	M2	2.526	2526	389.47	38.95		
	M3	2.621	2621	358.27	35.83		
28 days	M1	2.378	2378	427.00	42.70	2446.333	43.28
	M2	2.282	2282	416.00	41.60		
	M3	2.679	2679	455.4	45.54		

TABLE 9: RESULT FOR COMPRESSION TEST FOR 10% REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m³)	Failure load (KN)	Compressive strength (N/mm²)	Average density (kg/m³)	Average compressive strength (N/mm²)
7 days	M1	2.335	2335	316.87	31.69	2405.000	32.70
	M2	2.510	2510	338.56	33.86		
	M3	2.370	2370	325.57	32.56		
14 days	M1	2.253	2253	408.66	40.87	2345.333	38.53
	M2	2.491	2491	369.24	36.92		
	M3	2.292	2292	378.00	37.80		
21 days	M1	2.266	2266	419.56	41.96	2359.667	43.20
	M2	2.393	2393	421.89	42.19		
	M3	2.420	2420	454.55	45.46		
28 days	M1	2.278	2278	446.80	44.68	2373.000	45.43
	M2	2.294	2294	476.84	47.68		
	M3	2.547	2547	439.26	43.93		

TABLE 10: RESULT FOR COMPRESSION TEST FOR 15% REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7 days	M1	2.441	2441	282.43	28.24	2335.333	28.61
	M2	2.224	2224	279.54	27.95		
	M3	2.341	2341	296.42	29.64		
14 days	M1	2.410	2410	346.21	34.62	2390.667	35.76
	M2	2.371	2371	367.54	36.75		
	M3	2.391	2391	358.93	35.89		
21 days	M1	2.414	2414	421.21	42.12	2359.667	39.14
	M2	2.441	2441	337.68	33.77		
	M3	2.462	2462	415.28	41.53		
28 days	M1	2.417	2417	398.81	39.88	2487.667	40.48
	M2	2.511	2511	417.21	41.72		
	M3	2.535	2535	398.47	39.85		

TABLE 11: RESULT FOR COMPRESSION TEST FOR 20% REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7 days	M1	2.927	2927	278.45	27.85	2634.333	30.18
	M2	2.432	2432	248.56	24.86		
	M3	2.544	2544	257.55	25.76		
14 days	M1	2.399	2399	324.23	32.42	2462.667	36.31
	M2	2.456	2456	329.89	32.99		
	M3	2.533	2533	360.63	36.06		
21 days	M1	2.480	2480	387.12	38.71	2490.667	36.31
	M2	2.509	2509	345.79	34.58		
	M3	2.483	2483	356.36	35.64		
28 days	M1	2.561	2561	379.45	37.95	2487.667	38.50
	M2	2.470	2470	386.23	38.62		
	M3	2.432	2432	389.41	38.94		

TABLE 12: RESULT FOR COMPRESSION TEST FOR 25% REPLACEMENT OF COARSE AGGREGATE WITH RECYCLED COARSE AGGREGATE

(MIX RATIO 1:1:2)

Days	Sample	Weight (kg)	Density of sample cubes (kg/m^3)	Failure load (KN)	Compressive strength (N/mm^2)	Average density (kg/m^3)	Average compressive strength (N/mm^2)
7 days	M1	2.580	2580	256.76	25.68	2414.667	24.321
	M2	2.458	2458	246.19	24.62		
	M3	2.206	2206	226.68	22.67		
14 days	M1	2.436	2436	319.85	31.99	2599.333	32.47
	M2	2.810	2810	347.57	34.76		
	M3	2.552	2552	306.53	30.65		
21 days	M1	2.561	2561	348.96	34.90	2359.667	36.56
	M2	2.701	2701	362.78	36.28		
	M3	2.541	2541	343.12	34.31		
28 days	M1	2.686	2686	394.78	39.48	2599	38.10
	M2	2.591	2591	379.54	37.95		
	M3	2.520	2520	368.77	36.88		

TABLE 13: COMPRESSIVE STRENGTH SUMMARY

S/N	WASTE GLASS %	7TH DAY	14TH DAY	21ST DAY	28TH DAY
1.	0%	29.00	35.50	40	42.60
2.	5%	31.20	37.20	41.10	43.28
3.	10%	32.70	38.53	43.20	45.43
4.	15%	28.61	35.76	39.14	40.48
5.	20%	26.15	33.83	36.31	38.50
6.	25%	24.32	32.47	35.16	38.10

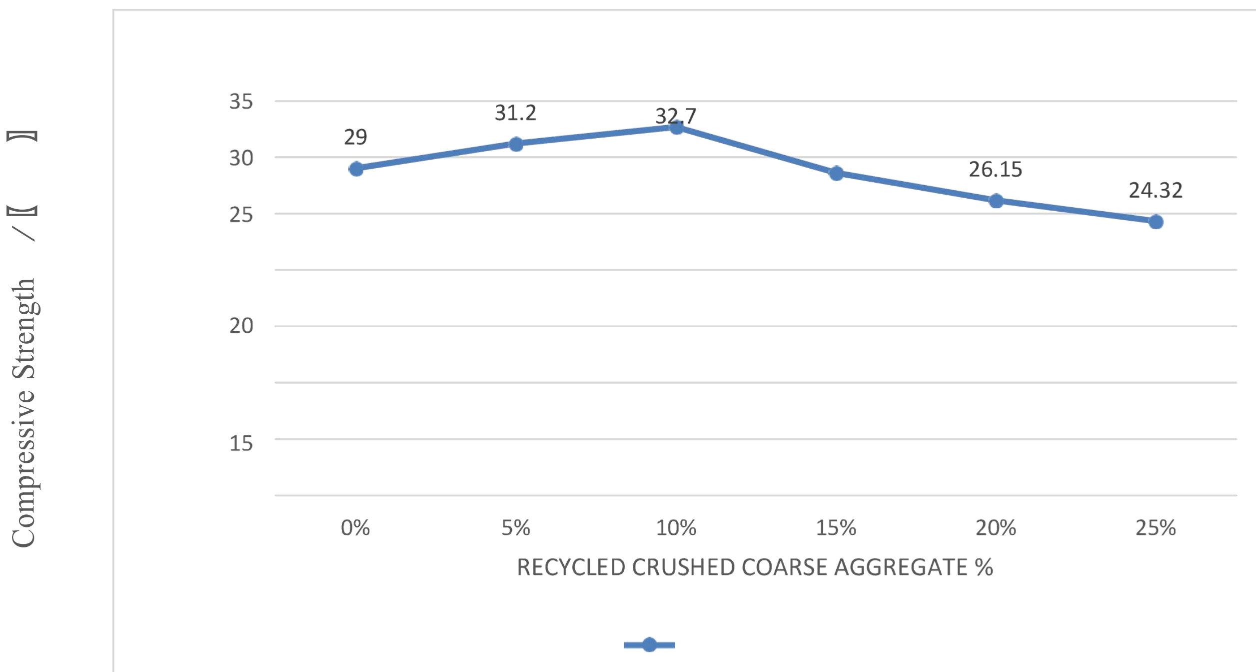

Figure 3: 7th Day

The graph above shows that the compressive strength of the cube increases with replacements of 5%, 10%, and 15%, 20%, and 25% of recycled crushed coarse aggregates, respectively, and decreases with additional increases. In contrast to Thomas et al(2016) .'s recommendation that recycled crushed coarse aggregate can be utilized to prepare structural concrete, it is noted that recycled crushed coarse aggregate can be replaced up to 10% after 7 days of curing. It has been proven through this research and the work of Thomas et al. (2016) that recycled crushed coarse aggregate can be employed.

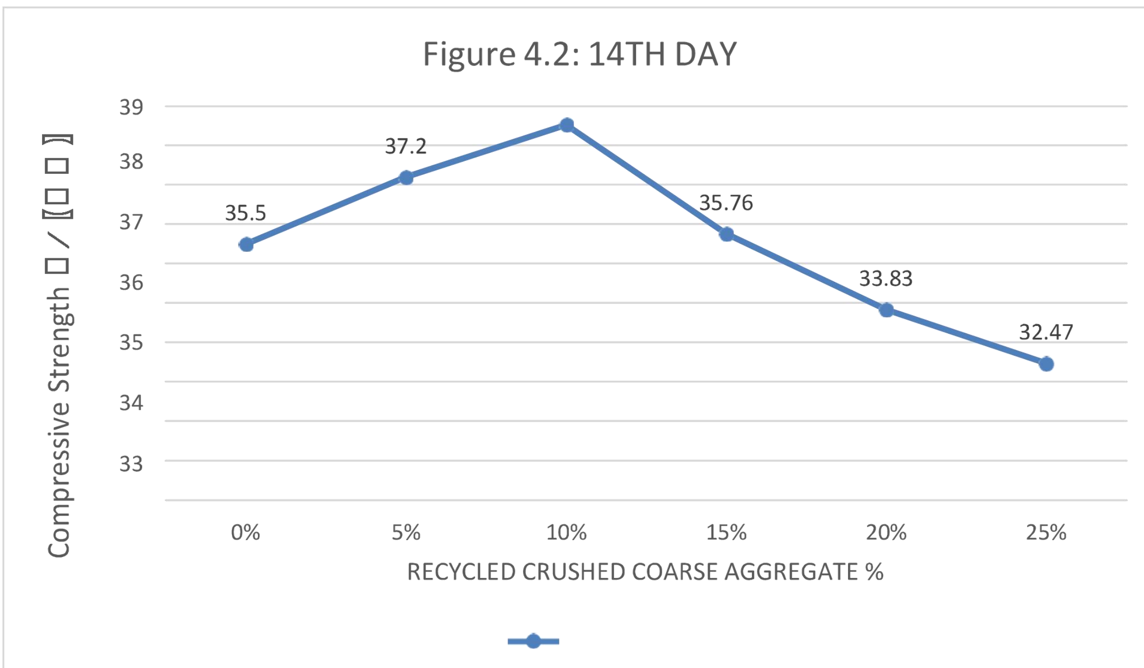

Figure 4: 14th Day

The same occurrence as figure.4.1

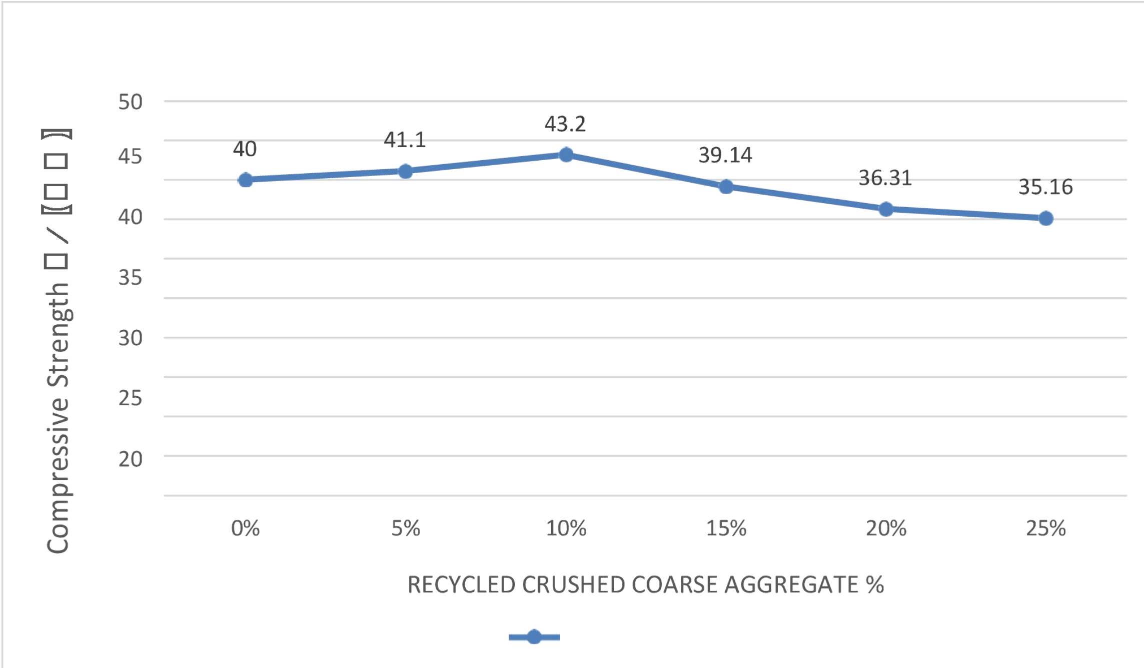

Figure 5: 21st Day

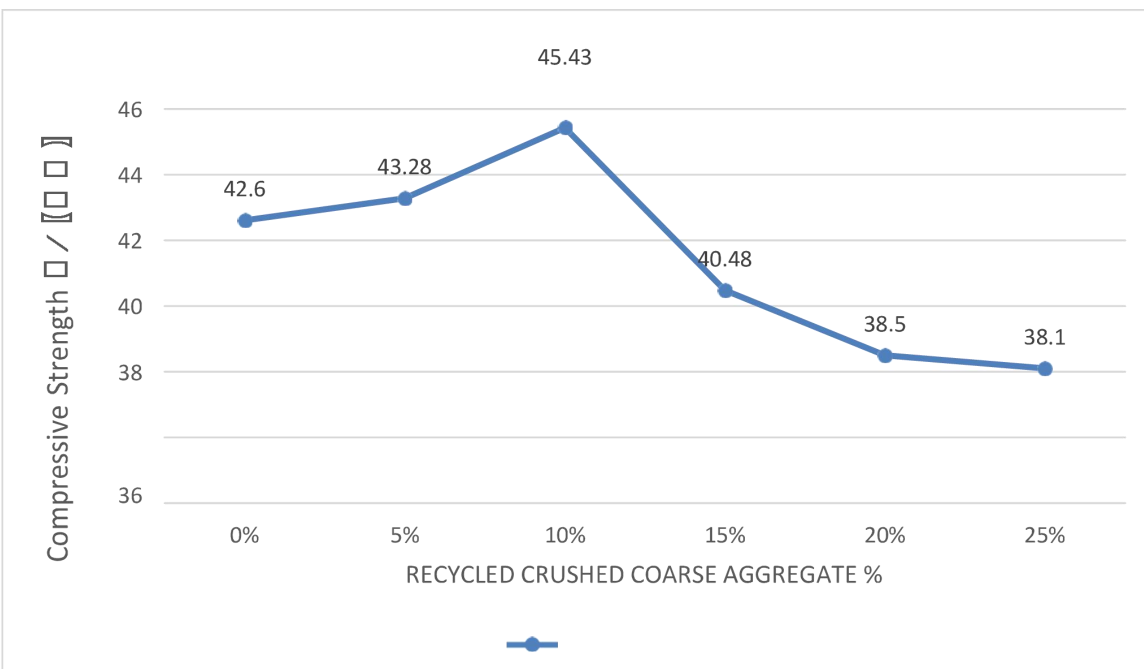

Figure 5: 28th Day

The same event from the seventh day is happening again on the twenty-eighth day. The graph above shows that the compressive strength of the cube increases with a replacement of 5%, 10%, and declines with a further increase of 15%, 20%, and 25% recycled crushed coarse aggregates. In contrast to Thomas et al(2016) .'s recommendation that recycled crushed coarse aggregate can be utilized to prepare structural concrete, it is noted that recycled crushed coarse aggregate can be replaced up to 10% after 7 days of curing. It has been proven through this research and the work of Thomas et al. (2016) that recycled crushed coarse aggregate can be employed. RCA has greater water absorption, impact value, and bulk density than natural coarse grains.

The experimental investigations carried out in the laboratory to determine the strength properties of the concrete with the additional mixture of crushed waste coarse concrete and test results are discussed. As per design obtained in accordance to BS Standard, mix proportion of various materials (viz. Cement, Coarse Aggregate, Fine Aggregate and Water) is calculated for Mix ratio of 1:1:2 grade of concrete. The cubes were casted and tested in the laboratory. The results of compressive strength of cubes for 7, 14, 21, and 28 days for various mixes.

The compressive strength for 5% 10%, 15% and 20% replacement of coarse aggregate by waste coarse concrete were compared with conventional/natural concrete.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATION

5.0 CONCLUSION

Based on the experimental study of investigating the use of demolished concrete waste concrete in concrete, the following conclusions which are limited to the materials used in the study.

i. This concrete is environmentally favorable since it consumes the trash produced when concrete is demolished, reducing its stagnation.

ii. Demolished aggregate possess relatively lower bulk crushing, density and impact standards and higher water absorption as compared to natural aggregate.

iii. This process can save up to the full cost of cement purchased via the traditional way.

Cost savings as a percentage rises with with mix design richness.

iv. Concrete made with crushed aggregate has a compressive strength that is up to 10% lower than concrete made with natural aggregate.

v. Concrete gains early strength and hence shuttering can be removed early thereby reducing the secondary overhead copy.

vi. The results of tests on coarse aggregates from demolished buildings and comparisons to natural coarse aggregates meet BS Standard requirements..

vii. According to the test results of compressive strength, the ideal replacement of fine aggregate is accomplished at a 10% replacement of fine aggregate by waste from destroyed concrete strength..

viii. There is a chance that some of the fine aggregate could be replaced by the rubbish created when a construction site is dismantled..

5.1 RECOMMENDATION

i. From the experiment, it is seen that recycled coarse aggregate can be used replace actual coarse aggregate.

ii. Government should make roof for easy access in carryout subsequent work on this related topic.

iii. Recycled Coarse Aggregate can be used to partially replace coarse aggregate.

REFERENCES

Dabhade, A.N., Dr. Choudhari, S.R., Dr. Gajbhiye A.R., (2012) Performance Evaluation Of Recycled Aggregate Used In Concrete, IJERA 2(4): 1387-1391.

Demolished trash as coarse aggregate in concrete by Mohd Monish, Vikas Srivastava, V.C. Agarwal, P.K. Mehta, and Rakesh Kumar (2013) (9).

Dhir, R.K., Limbachiya, M.C. and Leelawat, T. (1999) Suitability of recycled concrete aggregate for use in BS 5328 designated mixes, Proc. of Civil Engg. Struct. Build, 134: 257-274.

India's New Delhi Center for Science and Environment 2014. WASTE FROM DEMOLITION Achu Training Manual on Construction and Demolition Waste Management in India for Cities and Towns,

Kumutha, R. and Vijai, K., (2010) Strength of concrete incorporating aggregates recycled from demolition, ARPN Journal of Engineering and Applied Sciences, 5 (5): 64-71.

Masood, A., T. Ahmad, M. Arif, and F. Mahdi. concrete waste management techniques. Policy. Environ. Eng. 3: 15–18.

Performance of b brick aggregate concrete at high temperatures, Khalaf, F.M. and DeVenny, A.S. 2004. Civil Engineering Journal 16(6): 556-565.

R. Sekhar, Krishna Chandran, and Vaibhav Rathi, 2017, New Delhi, India Ramakrishna Hegde and others, 2018. "A Study on Strength Characteristics of Concrete by Replacing Coarse Aggregate by Demolished Column Waste." International Journal of Engineering Ressearch & Technology 7(6): 386-95.

Strength of recycled concrete constructed from coarse and fine recycled concrete aggregate, Hansen, T.C., and Marga, M. 1992. Ibid .135: 605-612.

Tarek Uddin Mohammed and colleagues 2014. Concrete recycled into coarse aggregate using brick aggregate. B4014005(January): 1–9 Journal of Materials in Civil Engineering

Use of recycled concrete aggregate in high strength concrete was reported by Limbachiya, Leelawat, and Dhir in 2000 in Materials & Structures, 33: 574–580.