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COMPARATIVE STUDY OF RECYCLED CEMENT CONCRETE USING DEMOLISHED AGGREGATES (FINE AND COARSE) WITH CONVENTIONAL CEMENT CONCRETE TO REDUCE ENVIRONMENTAL PROBLEM CAUSED BY DEMOLISHED CONSTRUCTION WASTE DEPOSITS

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ABSTRACT

Construction demolitions wastes (CDW) generated from construction industries, most times end up in damping sites (including landfills and swamps) where they contaminate the environment. As the global demand for concrete increases with a consequential increase in the consumptions of its components, the use of alternative materials as components in concrete will create a pathway to meet the future demand for concrete. One of the sustainable way forward is replacing the most voluminous component of concrete (i.e. aggregates) with CDW. However, in order to use CDW as aggregates, it needs to undergo processing which turns it into recycled aggregate (Adeyemi,2010). The construction industry in Rwanda especially Kigali city has shown rapid growth due to Kigali City Master Plan (KCMP). The common construction material currently used in urban area is concrete that can be broken during construction or demolishing activities. Demolition work generates construction waste materials that should be well deposited and managed otherwise they highly affect environment in different ways including environmental degradation caused by the activity of materials extraction and later by damped demolished wastes. This study was mainly aimed on comparative study on compressive strength of normal cement concrete and cement concrete made by recycled aggregates and how we can decrease the amount of construction waste materials which are still big problem in its disposal conditions by reusing construction and demolition wastes. The work composed of the collection of samples of concrete wastes, which were crushed, batched and mixed with a proportion of 1:1.7:2.7. Then recycled coarse and fine aggregates were used in casting concrete cubes having dimension 150mm×150mm×150mm to be compared by concrete cubes casted using normal coarse and fine aggregates. The results from the test with prepared concrete cubes at 28 days showed that the average compressive strength of concrete cubes of normal coarse and fine aggregates was 31.815 N/mm^2 while the average compressive strength of concrete cubes of recycled coarse and fine aggregates was 28.339N/mm^2. With this results, researchers found that the concrete material from recycled coarse and fine aggregates have 10.9% compressive strength lesser than that of concrete material from normal coarse and fine aggregates. Researchers conclude that the concrete material composed of recycled coarse and fine aggregates due to its less compressive strength, it should be used in pavement blocks, drainage system construction, light weight building construction so as to minimize the huge quantity of construction and demolition waste (C&D wastes) IS 4031 (Part-1):1988.

KEYWORDS: Construction demolition wastes, recycled concrete, normal concrete, compressive strength.

INTRODUCTION

Concrete is one of the most widely used construction material obtained by mixing together cement, aggregates, water and sometimes admixtures. The mixture when placed in forms and allowed to cure, it hardens into a rock like mass. The quality of concrete is exclusively dependent on the quality of its ingredients and the workmanship for concrete making and placing. IS 4031 (Part-1):1988.

Cement is obtained by grinding various raw materials after calcination. The degree to which cement is ground to smaller and smaller particles is called fineness of cement. The fineness of cement has an important role on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence the faster development of strength although the ultimate strength is not affected. Fineness also provides more cohesiveness to concrete and avoid separation of water at the top of concrete (called bleeding). However, increase in fineness of cement increases the drying shrinkage and cracking of the concrete. IS 4031 (Part-1):1988.

Aggregates are granular materials that include river sand, gravel, crushed stone, and may occupy up to 75% of the concrete's total volume. Since aggregates are less expensive than cement paste, they are added to concrete to help reduce costs. The properties of aggregates can have a significant effect on the workability of concrete in its plastic state, as well as the durability, strength, density, and thermal properties of the hardened concrete. The principal considerations on the quality of mixing water are related to performance in fresh as well as harden state. The quality of the water plays an important role in the preparation of concrete. Impurities in water may interfere with the setting of the cement and may adversely affect the strength and durability of the concrete also. The chemical constituents present in water may actively participate in the chemical reactions and thus affect the setting, hardening and strength development of concrete. In addition to that, health issues related to the safe handling of such water must be considered (Ahmed , 2015).

Recycled concrete aggregate is generally produced by the crushing of concrete rubble, screening then removal of contaminants such as reinforcement, paper, wood, plastics and gypsum. Concrete made with such recycled concrete aggregate is called recycled aggregate concrete. The main purpose of this work is to determine the basic characteristic strength or properties of Recycled concrete made of coarse and fine recycled concrete aggregate then to compare them to the properties of concrete made with natural coarse and fine aggregate concrete. Recycling and waste reduction both are extremely important elements in the framework of waste management, because they help to preserve mainly the natural resources and reduce demand for valuable landfill space (Anteneh Geremew , 2018). Currently in Rwanda, there is no estimated amount of construction and demolition waste while implementation of Kigali City Master plan is going on. This is a big challenge in management of concrete waste due to the shortage of damping sites and this will result in environment degradation and biodiversity destruction. Thus the idea of using recycled concrete aggregate in new concrete production appears to be an effective utilization of concrete waste (Ahmed ,2015).

Recycled aggregate is a waste material collected from demolished concrete structure. For this study, the recycled aggregates were collected from a demolished concrete structure of former

SONARWA in Kigali city-Rwanda, Nyarugenge district where the existing structure was demolished to provide a new site for another project.

1.2. PROBLEM STATEMENT

Construction demolished wastes are very harmful to the environment due to their illegal deposition by different construction industries. These harmful impacts to the environment include; landfill, biodiversity destruction, air pollution, erosion, water pollution, impacts on health and welfare of people.

This research work aimed to help in decreasing the environmental problems caused by deposition of construction waste materials in order to deal with recycling of demolished concrete components (fine and coarse aggregates) in new concrete production in order to decrease the quantity of construction demolished wastes deposits.

1.3 RESEARCH OBJECTIVES

The objectives of this project are to compare concrete strength for conventional cement concrete and recycled cement concrete using both recycled coarse and fine aggregates in place of conventional concrete by establishing the way of decreasing the amount of construction wastes deposits on the surface that can be used for other purposes.

1. To determine concrete strength for both conventional and recycled cement concrete.
2. To compare the strength characteristics for both conventional cement concrete and recycled cement concrete using both recycled coarse and fine aggregates.
3. To determine concrete water absorption for both conventional cement concrete and recycled cement concrete using both recycled coarse and fine aggregates.

LITERATURE REVIEW

Making concrete using both recycled coarse and fine aggregates (RCA) can be sustainable ,environmental protection and cost-saving when compared to conventional concrete. However, the quality of concrete made with RCA is dependent on the quality of the recycled material used (Jason ,2014).

2.1 PREVIOUS RELATED STUDIES

Ashraf M. Wagih, et al(2012**)** conducted an experiment study on Recycled construction and demolition concrete waste as aggregate for structural concrete. The study discussed the possibility to replace natural coarse aggregate (NA) with recycled concrete aggregate (RCA) in structural concrete. An investigation into the properties of RCA was made using crushing and grading of concrete rubble collected from different demolition sites and landfill locations around Cairo. Aggregates used in the study were: natural sand, dolomite and crushed concretes obtained from different sources. Tests were carried out for compressive strength, splitting strength and elastic modulus. The results showed that the concrete rubble could be transformed into useful recycled aggregate and used in concrete production with properties suitable for most structural concrete applications in Egypt. A significant reduction in the properties of recycled aggregate concrete (RAC) made of 100% RCA was seen when compared to natural aggregate concrete (NAC), while the properties of RAC made of a blend of 75% NA and 25% RCA showed no significant change in concrete properties.

Jackson, et al (2014), researchers worked toward developing reliable standards for the use of recycled concrete aggregates in new concrete. They conducted accelerated laboratory tests to assess how well recycled concrete aggregates resisted breaking down due to alkali-silica reaction. They cast concrete blocks containing recycled aggregates in outdoor exposure site to establish long-term data about their performance and durability. They developed a formula for using supplementary cementitious materials to strengthen recycled concrete aggregates.

With their enough and strong performance, they concluded that; recycled concrete aggregates have a potential to lessen environmental impact of new construction project.

Yadhu, et al (2015), reused the demolished concrete waste as fine aggregate. From the study, the compressive strength of concrete with crushed demolished waste as a replacement of fine aggregate had a lower value than the normal concrete. However, it could be used in construction members that do not carry much load. Thus, in general, they concluded that the crushed demolished and construction waste can be used as a replacement of conventional sand as a fine aggregate but needs further investigation into how extensively it can be used as a replacement.

Medhat, et al (2016), investigated the properties of the recycled concrete aggregate of high quality that were produced through the technique of preserving the original properties of the aggregate. As per the comparison made on the effect of recycled concrete aggregate and commercial recycled concrete aggregate, the preserved quality had better compressive strength, drying shrinkage, and salt scaling resistance.

Martinelli, et al (2015), investigated the procedure of removing impurities of recycled concrete aggregate and examined their influence on physical and mechanical properties of concrete at fresh and hardened states. The researchers came with the feasibility of autogenous cleaning that could remove the surface impurities of recycled concrete aggregate as well as reduce particle heterogeneities. To reduce heterogeneity, they removed the residual wood, plastics, and steels from demolished debris,and to reduce the amount of fine particles attached on the surface of recycled concrete, autogenouscleaning was performed. The cleaning procedure enhanced the recycled aggregate quality, and this sustainability improved the properties of the concrete with recycled aggregate at fresh and hardened states. The fine particles attached on the surface of the recycled concrete aggregate increased the water absorption capacity of recycled fine aggregate and also had a lower density than natural aggregate. Thus, the compressive strength was less than the conventional concrete due to the high water absorption capacity of the recycled fine aggregates.

Park, et al (2018) evaluated the surface modification of recycled fine aggregate to reduce the water absorption rate and increase density by aqueous H2SiF6 solution. The modified recycled aggregate showed more improvement than the recycled aggregate before modification in mechanical properties of both compressive and flexural strength. Thus, they concluded that the surface treatment method using the H2SiF6 solution is effective in improving high water absorption capacity and low density of recycled fine aggregates.

Fayissa, et al (2018), conducted an experiment for comparing the impact value and the crushing value of normal and recycled aggregate. The coarse aggregate (C.A) was separated from the concrete by hammering. Mortar adhered to the aggregate is also removed from the aggregate as much as possible. Obtained C.A is sieved under 20mm sieve (passing) and 4.75mm sieve (retained), later these aggregates can be used as R.C.A for further work. Natural aggregate was replaced by recycled aggregate with various percentages of 0%, 25%, 50%, 75%, and 100% correspondingly. The compressive strengths were noted by crushing the cubes at 7, 14, 21 and 28 days of curing. Based on the experiment results, concluded that the specific gravity, the elongation index, the flakiness index, the bulk unit weight, the absorption capacity, the impact value and the crushing value of the recycled coarse aggregate is less than the natural aggregates.

Atik, et al (2017), Conducted a study to find the suitability of RCA. RCA was collected from demolition waste of pile head from a local construction site. Three different combinations of natural coarse aggregate (NCA) and RCA were used to produce three different coarse aggregate mixtures to be used in producing concrete. From each combination, three cylindrical concrete samples were prepared and subjected to compression and tensile tests at 7, 21 and 28 days. The nominal ratio of cement, sand and coarse aggregates were kept at 1:1.5:3 by weight for all mixes. In all than their RCA concrete samples. But in terms of economy and environmental sustainability it is a negotiable issue to reuse RCA in simple construction works like boundary wall, landfill work etc. The tests of pavement materials like aggregate impact value (AIV) test and aggregate crushing value (ACV) test were also performed to evaluate RCA performance in pavement constructions. Satisfactory results determined here encourages the use of RCA in pavement constructions.

Magda, et al (2013), conducted a study discussing the possibility to replace natural coarse aggregate (NA) with recycled concrete aggregates (RCA) in structural concrete. Aggregates used in the study were: natural sand, dolomite and crushed concretes obtained from different sources. He studied the effect of recycled coarse aggregates quality/content. Tests were carried out for: compressive strength. The results showed that the concrete rubble could be transformed into useful recycled aggregate and used in concrete production with properties suitable for most structural concrete applications in Egypt. A significant reduction in the properties of recycled aggregate concrete (RAC) made of 100% RCA was seen when compared to natural aggregate concrete (NAC), while the properties of RAC made of a blend of 75% NA and 25% RCA showed no significant change in concrete properties.

Maxima, et al (2021), conducted a study aimed on Recycled aggregates (RA) from construction and demolition waste (CDW) instead of natural aggregates (NA) in the manufacture of new eco-friendly concrete. Fine (FRA) and coarse (CRA) recycled aggregates were used in different percentages as substitutes of natural sand and gravel, respectively. The results revealed that the use of RA in percentages of up to 50 wt.% is feasible. Additionally, RA were used to produce paving blocks in accordance with industrial requirements. Thus, values of water absorption lesser than 6.0% and tensile strength upper than 3.6 MPa were obtained, which are similar to those of a reference sample and within the limit values established by the regulations. These results were achieved by reducing the incorporation of cement, thereby saving production costs and minimizing environmental impact.

MATERIALS USED AND THEIR PROPERTIES

3.1 The materials used for experimental study

Recycled Construction waste materials such as coarse and fine aggregates, and normal concrete materials together with cement were used for preparing both cycled and conventional concrete to compare the strength characteristics between them and prevent environmental problems by reducing demolished waste deposition.

1). Cement

Portland cement is made by blending an appropriate mixture of limestone and clay or shale together, and by heating them to 1450◦C in a rotary kiln after add gypsum, Gypsum added is to control fast setting caused by 3CaO · Al2O3. We used the cement which has compressive strength of 32.5 M (JOEL).

Portland Cements and Blended Cements are hydraulic, since they set and harden to form a stone-like mass by reacting with water. The term Hydraulic Cement is all inclusive and is the newer term to be used for both Portland Cement and Blended Cement.

Table 1: Properties of cement used.

Particulars (tests)	Results obtained	References
Type of cement	32.5 grade OPC	IS: 12269
Normal Consistency	20 min.	IS: 269 -1976
Specific Gravity	3.15	IS: 269 -1976
Setting time (in min) (a) Initial setting time (b) Final setting time	 201 min. 429 min.	IS: 269 -1976 Should be not less than 30 minutes Should not be more than 600 minutes
Soundness	7mm	Blain's air permeability test
Fineness	$225m^2$/kg.min	M. JOEL comparative of cement grade in concrete

2). Normal coarse and fine aggregates

Coarse aggregates: Aggregates predominately retained on a No. 4 (4.75-mm) sieve are classified as coarse aggregate. Generally, the size of coarse aggregate ranges from 5 to 150 mm. For normal concrete used for structural members such as beams and columns, the maximum size of coarse aggregate is about 25 mm. For mass concrete used for Dams or deep foundations, the maximum size can be as large as 150 mm.

Figure 1: Normal coarse aggregates.

Fine aggregates: Aggregates passing through a No. 4 (4.75 mm) sieve and predominatelyretained on a No. 200 (75μm) sieve are classified as fine aggregate. River sand is the most commonly used fine aggregate. In addition, crushed rock fines can be used as fine aggregates. However, the finish of concrete with crushed rock fines is not as good as that with river sand.

Figure 2: Normal fine aggregates.

Properties of the coarse aggregate and fine aggregate used

The specific gravity and fineness modulus, Water absorption and Moisture content for both fine aggregate and coarse aggregate were determined according to the norms of the Indian Standards as per IS: 383:1970 and the sand was tested as per IS: 2386:1963 (IS: 2386 Part I 1963) as the results are given bellow.

Table 2: Normal fine aggregate.

SI.No	Particulars	Results obtained	References
1.	Fineness modulus	3.77	IS: 2386 (Part III)-1963
2.	Specific gravity	2.65	IS: 2836(Part III)-1963, IS:383-1970 ,IS: 460-1962
3.	Grading zone	Zone-II	IS: 383-1963
4.	Water absorption	1%	---
5.	Moisture content	NIL	---

Table 3: Normal coarse aggregate.

SI.No	Particulars	Results obtained	References
1.	Fineness modulus	7.71	IS: 2386 (Part III)-1963
2.	Specific gravity	2.67	IS: 2836(Part III)-1963 IS: 383-1970 IS: 460-1962
3.	Water absorption	1.63%	IS :2386.3.1963
4.	Moisture content	NIL	---

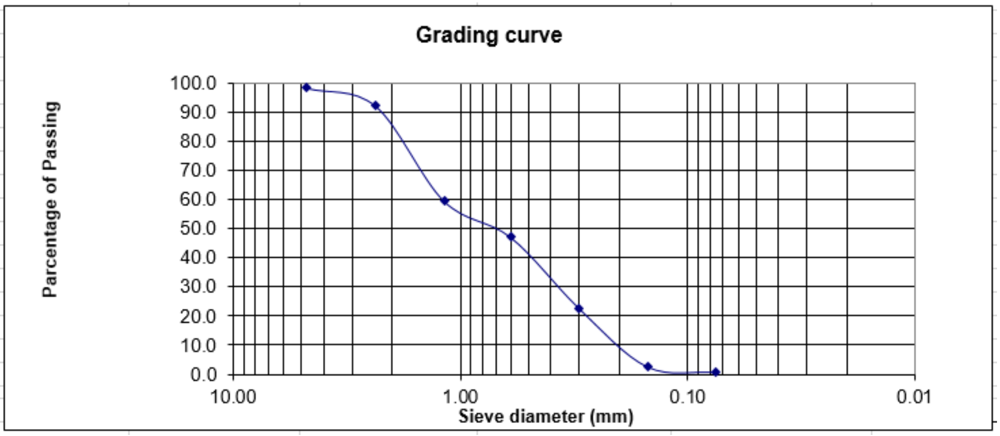

Figure 3: Particle size distribution graph for Normal fine aggregates.

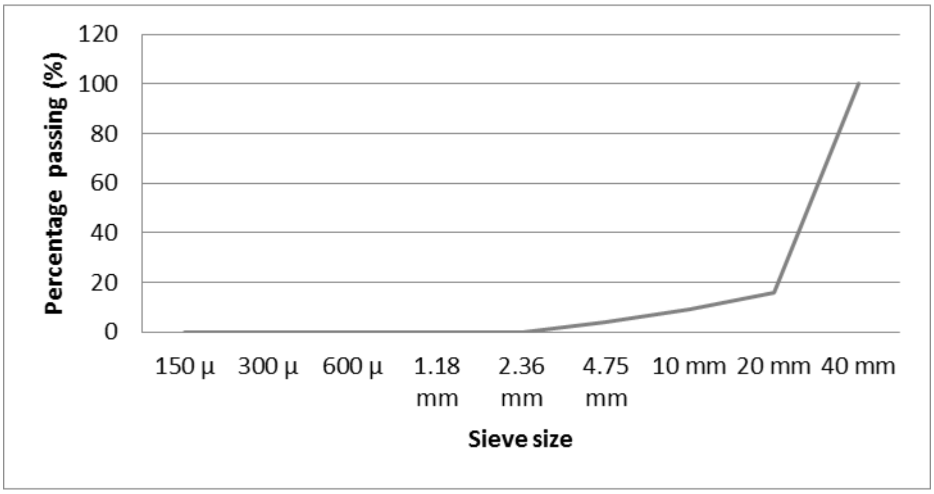

Figure 4: Particle size distribution graph for normal coarse aggregates

3). Recycled coarse and fine aggregates

Coarse and fine aggregates from recycled concrete: Since the recycled aggregate has different properties than Natural aggregate, it behaves differently in concrete mixes and causes the finished concrete to perform unlike conventional concrete (Katrina). Recycled coarse and fine aggregates used in this study were collected from demolished concrete structure of

SONARWA. The size of normal coarse aggregates used was 20mm with water absorption value of 2.8%. Fineness modulus for recycled fine aggregates was 3.45.

Figure 5: Recycled coarse and fine aggregates.

Properties of recycled coarse and fine aggregate used

The properties for both recycled fine aggregate and coarse aggregate were determined according to the norms of the Indian Standards as per IS: 383:1970 and the sand was tested as per IS: 2386:1963 (IS: 2386 Part I 1963) as shown bellow.

Table 4: Recycled fine aggregate.

SI. No	Particulars	Results obtained	References
1.	Fineness modulus	3.45	IS: 2386 (Part III)-1963
2.	Specific gravity	3.58	IS: 2836(Part III)-1963, IS:383-1970 ,IS: 460-1962
3.	Grading zone	Zone-II	IS: 383-1963
4.	Water absorption	1.5%	---
5.	Moisture content	NIL	---

Table 5: Recycled coarse aggregate.

Particulars	Results/values obtained	References
Fineness modulus	7.80	IS: 2386 (Part III)-1963
Specific gravity	2.65	IS: 2836(Part III)-1963 IS: 383-1970 IS: 460-1962
Water absorption	1.93%	IS :2386.3.1963

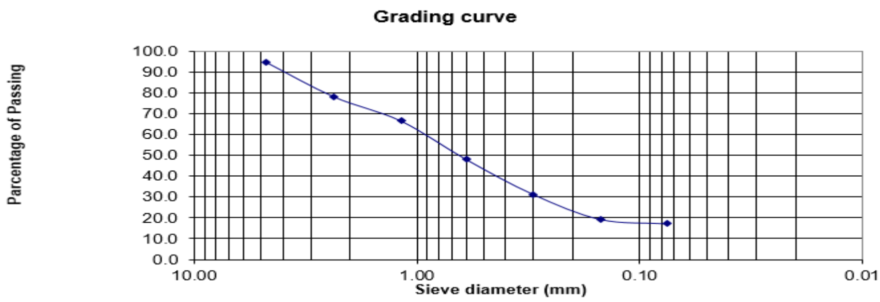

Figure 6: Particle size distribution graph for recycled aggregates.

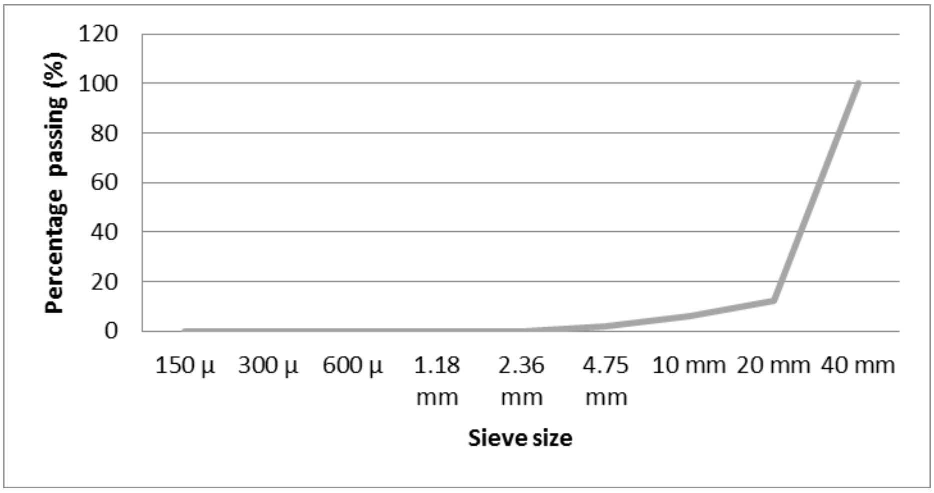

Figure 7: Particles size distribution graph for recycled coarse aggregates.

4). Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. The water used for mixing and curing should be clean and free from harmful materials and substances that may be deleterious to concrete properties and steel. Portable water is generally considered satisfactory for concrete mixing process. The PH value of water to be used should not be less than six. The portable water available in the laboratory taps conforming to the requirement of water for concreting and curing as per IS: 456-2000 was used in this project work for concrete production process.

3. METHODOLOGY

In this experiment work, the methodology conducted for this research work was determined and discussed. This investigation was carried out to study the Comparison on the strength characteristics between conventional cement concrete and cement concrete using recycled coarse and fine aggregates. The 15mm*15mm*15mm cubes specimens from normal and recycled concrete mixes were cast, then cured for 28days. The following are methodologies adopted to achieve the objectives of this research project.

To conduct comprehensive literature review related to subject of recycled concrete materials. Selection of suitable ingredient materials required for concrete production including cement, aggregates, water. Performing physical and mechanical laboratory tests on both normal and recycled aggregates including observation, sieve analysis, specific gravity and water absorption.

Determine the relative quantities of concrete materials in order to produce concrete mix and casting of concrete specimens and curing them for 3, 7and 28 days.

To compare strength characteristics between conventional cement concrete and recycled cement concrete using recycled coarse and fine aggregates.

For concrete water absorption, cubes specimens for normal concrete and recycled concrete were prepared for water absorption test. Concrete water absorption was tested after 28 days of curing period. The oven-dry mass of each specimen was obtained and noted as the dry weight W2 of the specimen. The saturated mass (using immersion of cube specimens in water) of samples was determined and noted as the wet weight W1 of the specimen. The condition and the procedures for concrete water absorption test were considered and described careful step by step as shown clearly in this section as per ASTM C642.

The results for percentage concrete water absorption were determined for average weight of three specimens taken into account and the amount of water absorbed under specified conditions was determined.

Concrete water absorption after immersion, % = $[(W1- W2)/ W2] \times 100$

Where: W2: Mass of oven-dried sample (in gm), W1: Mass of surface-dry sample in air after immersion (in gm).

5. EXPERMENTAL STUDY

5.1. Concrete Mix Design Used For both Normal and Recycled Concrete

In this study, the concrete mix was designed according to IS: 10262:2009. The mix proportioning of concrete was done by selecting M25 grade concrete and water cement ratio of 0.47 for both conventional and recycled based concrete mixes in order to study concrete strength when using different ingredient materials and same curing methods.

The mix proportions obtained was determined based on the field condition such as free surface moisture and water absorptions of aggregates as per IS:2386(part 3) and the final concrete mix proportion per cubic meter obtained for both mixes are determined in the tables below.

Table 6: Concrete mix Design Stipulations and Test data of material.

1	Grade of concrete (designation)	M25
2	Type of cement	OPC 32.5 Grade
3	Minimum normal size of aggregate	20mm
4	Workability	90-100 mm (Slump)
5	Exposure condition	Moderate
6	Method of concrete placing	normal
7	Degree of supervision	Good
8	Specific gravity of cement	3.15
9	Specific gravity of normal coarse aggregate	2.67
10	Specific gravity of normal fine aggregate	2.65
11	Sieve analysis for normal fine aggregate	Zone 2(IS 383-1970)
	Specific gravity of recycled coarse aggregate	3.58
	Specific gravity of recycled fine aggregate	2.62
	Sieve analysis for recycled fine aggregate	IS: 2836(Part III)-1963, IS:383-1970 ,IS: 460-1962

Table 7: Concrete mix design for both normal and recycled concrete.

Water cement ratio (kg/m^3)	Water content (kg/m^3)	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
0.47	197	420	714.97	1175.335
		1	1.7	2.7

6. Sample Preparation

6.1 Mixing and Casting of the specimens

Before starting the mixing for the required quantity of materials for concrete, concrete ingredient materials are weighed accurately as per the mix proportioning done before. At first, the natural fine aggregates and cement are added into the concrete mixer, these materials dry mixed for a minute in the mixer followed by addition of coarse aggregate and again dry mixed for a minute. Then finally calculated amount of water is added with superplasticizer into the mixer and again mixed for 2 minutes. Both normal and recycled concrete specimens were casted separately to consider their fresh properties and the strength characteristics of concrete.

The specimens were cast for testing the mechanical properties of concrete such as compressive strength, water absorption. For compressive strength test, cubes of size 150mm×150mm×150mm were used. These cubes were filled with flesh concrete and compacted by using vibrating table. Specimen were cast from all concrete mixes. Cubes were cast for compressive strength test on both normal and recycled concrete and for concrete water absorption test. The specimens were demoulded from the moulds carefully after 24 hours of casting without any damage to the specimens.

Figure 8: Casting of specimen.

6.2 Curing of the concrete specimens

All specimens for both normal and recycled concrete were demoulded from the moulds and then immediately curing of the concrete specimens was done using the curing tanks in civil engineering laboratory CST (College of Science and Technology). After demoulding, the specimens reserved for compressive strength testing were kept in water until the days of testing 3, 7, and 28 days and those reserved for water absorption also tested at the same time interval as shown above.

Figure 9: Curing of concrete specimens.

7. RESULTS AND DISCUSSION

7.1 Fresh properties results for normal and recycled concrete mixes

To determine the fresh properties of concrete, slump test was carried out in the laboratory for both normal and recycled concrete mixes. Slump values using different kind of aggregates such as normal and recycled aggregates were obtained. It was observed that the average slump test results are 95 mm for normal concrete and 90mm for recycled concrete mixes.

7.2 Mechanical properties on both normal and recycled concrete

Tests were conducted on standard cubes specimens of 150 x 150 x 150 mm size, were carried out in laboratory for compressive strength testing for 3, 7, and 28 days of curing period, compressive strength results were obtained as per IS:516-1959.

In the present investigation, cubes casted were used for compressive strength test and water absorption test. For 3, 7 and 28 days compressive strength results of both normal and recycled concrete are given in the tables and figures below.

i) Compressive strength test results for normal cement concrete

Table 8: Average compressive strength result for normal hardened concrete

SI.NO	Number of specimen	Failure load (KN)	Average failure load (KN)	Average compressive strength(N/mm^2)	Days
1	1.	266.6	266.358	11.838	3
	2	264.01			
	3	268.465			
2	1	459.51	458.08	20.359	7
	2	458.2			
	3	456.54			
3	1	714.3	715.833	31.814	28
	2	715.5			
	3	717.7			

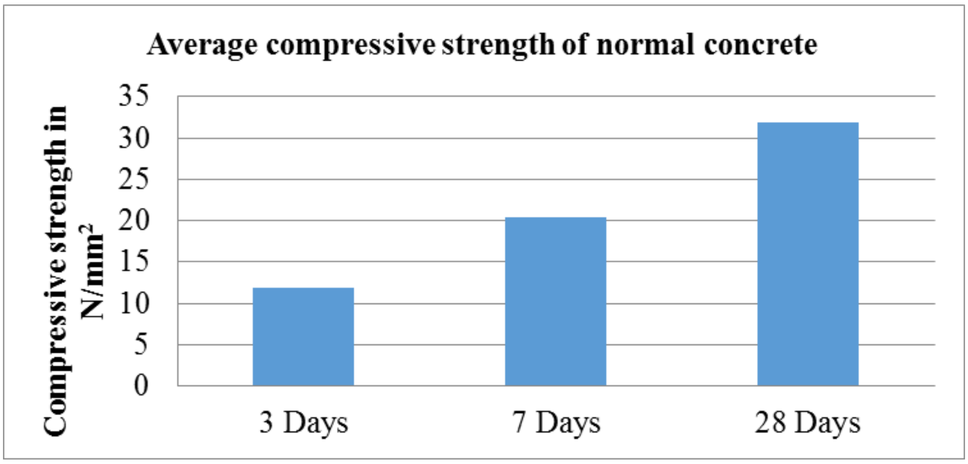

Figure 10: Compressive strength graph for conventional cement concrete.

ii) Compressive strength test results for recycled hardened concrete

Table 9: Average compressive strength result for recycled hardened concrete.

SI.NO	Number of specimen	Failure load (KN)	Average failure load (KN)	Average compressive strength(N/mm^2)	Days
1.	1	246.2	244.167	10.85	3
	2	244.1			
	3	242.2			
2.	1	398.4	398.28	17.70	7
	2	399.2			
	3	397.25			
3.	1	637.7	637.63	28.339	28
	2	639.94			
	3	635.25			

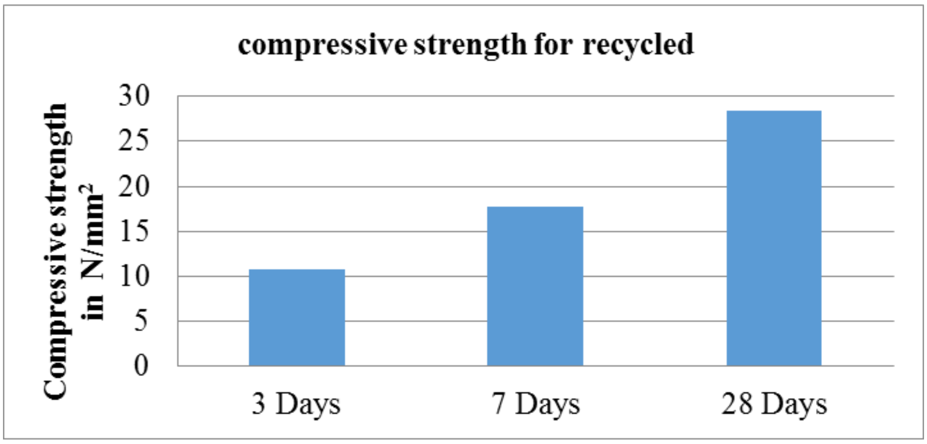

Figure 11: Compressive strength for recycled concrete

iii) Comparison of compressive strength between conventional cement concrete and cement concrete using recycled coarse and fine aggregates.

The compressive strength of conventional cement concrete and recycled cement concrete using both recycled coarse and fine aggregates was determined for 3, 7, and 28 days of curing.

For 3 days of curing, the compressive strength of conventional cement concrete is 8.33% greater than that of recycled concrete. The compressive strength for conventional cement concrete was 11.838 N/mm^2 while compressive strength for recycled cement concrete was10.85 N/mm^2.

For 7 days of curing, the compressive strength of conventional cement concrete is 13.01% greater than that of recycled concrete. The compressive strength of conventional cement concrete was 20.359 N/mm^2 while recycled cement concrete compressive strength was 17.71 N/mm^2.

For 28 days of curing, the compressive strength of conventional cement concrete is 10.9% greater than that of recycled concrete. Conventional cement concrete has compressive strength of 31.814 N/mm^2 while those for recycled cement concrete were 28.339 N/mm^2.

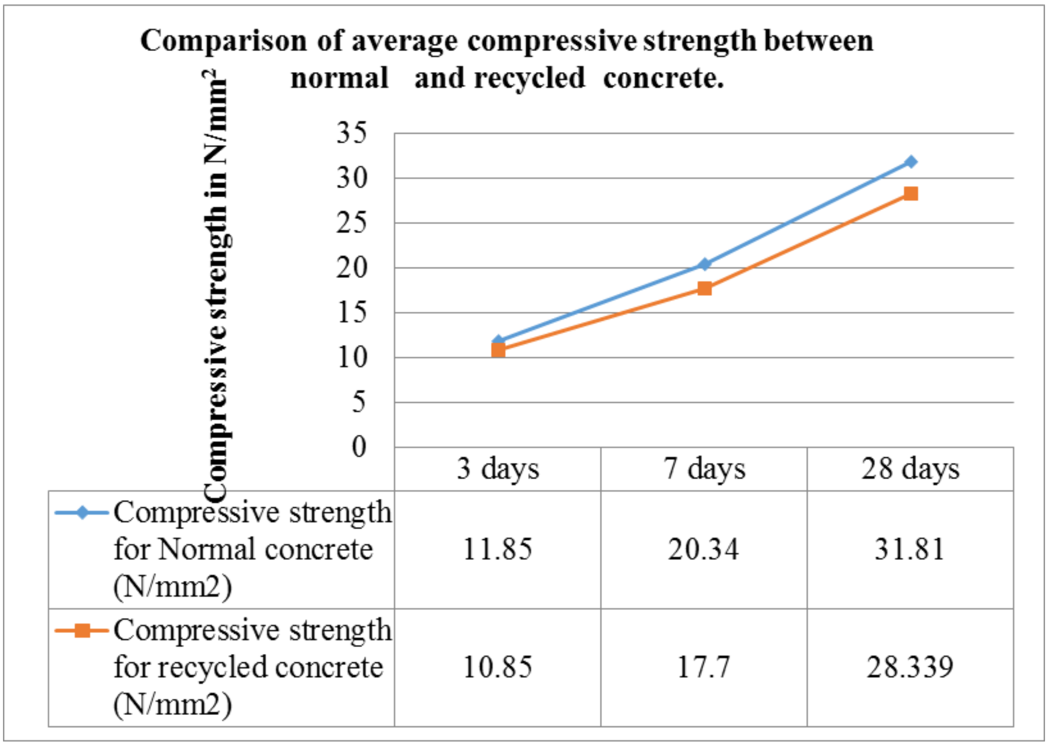

Figure 12: Comparison graph of both normal and recycled concrete.

7.3 CONCRETE WATER ABSORPTION TEST RESULTS

i. Concrete water absorption test results for conventional cement concrete

Water absorption test was determined after 28 days of curing.

Table 10: Water Absorption test results for conventional cement concrete.

Different environmental conditions for specimens samples	**Weight of sample specimens normal concrete (in kg)**			**Time of curing for spacemen's samples**
	SI. No	**Weight of samples (in kg)**	**Average weight (kg)**	
Oven-dry mass of each specimen (dry weight of the specimen for 24 hours),W2	1	8.62		
	2	8.46		28day
	3	8.56	8.55	
Saturated mass (using immersion) of samples in water(wet weight of the specimen)W1	1	8.78		28 days
	2	8.57	8.69	
	3	8.72		

W.A = [(W1-W2) *100] W1

= [(8.69-8.55) *100]/ 8.55

=1.63%

ii. Concrete water absorption test results for recycled concrete

Table 11: Water absorption test results for recycled concrete.

Different environmental conditions for specimens samples	**Weight of sample specimens of recycled concrete (in kg)**			**Time curing for specimen samples**
	SI. No	**Weight of samples (cubes in kg)**	**Average weight (kg)**	
Oven-dry mass of each specimen (dry weight of the specimen for 28 hours),W2	1	8.28		
	2	8.13		28 days
	3	8.34	8.25	
Saturated mass (using immersion) of samples in water(wet weight of the specimen), W1	1	8.41		
	2	8.21		28days
	3	8.61	8.41	

W. A= [(W1-W2) *100] W1

= [(8.41-8.25) *100)]/ 8.25

=1.93%

iii. Comparison in water absorption for both normal and recycled concrete

The results of percentage concrete water absorption after 28 days curing, cubes specimens for normal concrete and recycled concrete are described and presented in details as shown below.

The percentage of concrete Water Absorption test results for conventional cement concrete was 1.63% as compared to Water Absorption test results for recycled concrete of 1.93%.

The results show that the percentage of concrete water absorption for recycled concrete was increased up to 0.3% greater than that of normal concrete tested after 28 days.

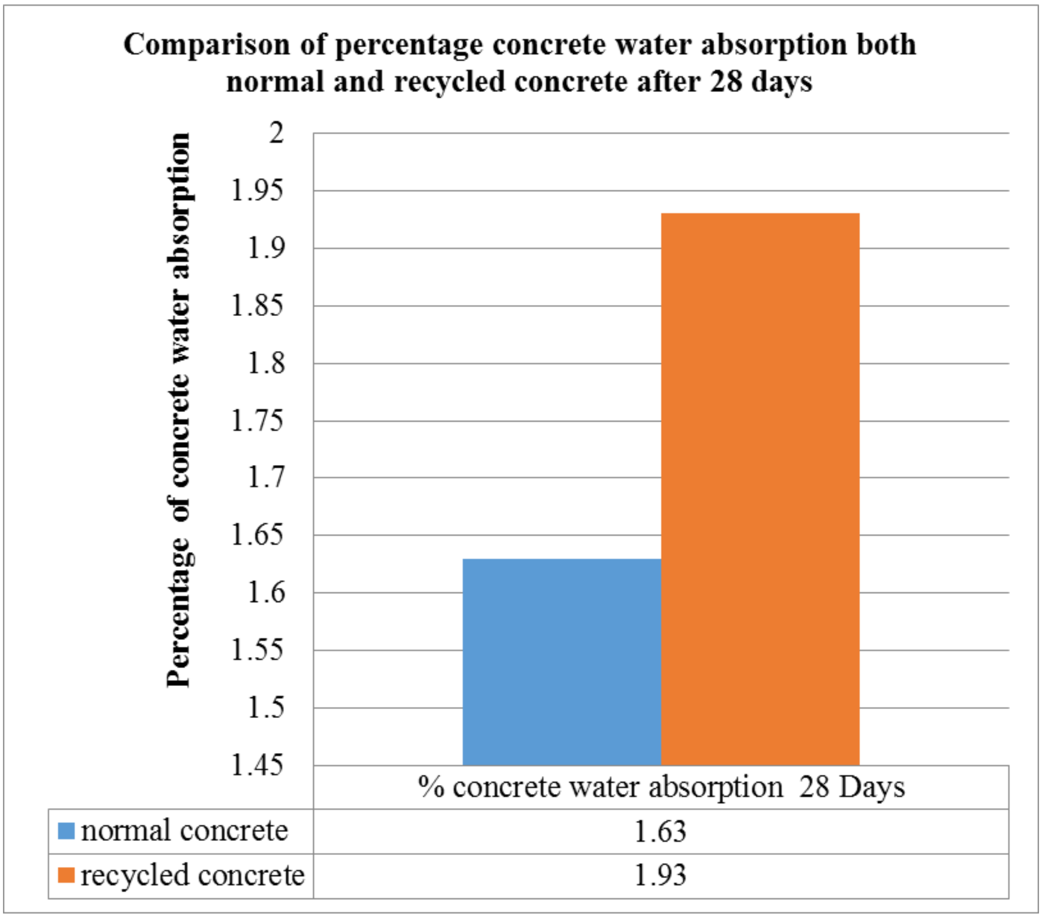

Figure 13: Comparison graph in water absorption for both normal and recycled concrete.

8. CONCLUSIONS AND RECOMMENDATON

Experimental investigation for this study on characteristics strength of the conventional cement concrete and recycled concrete using recycled coarse and fine aggregates have been done. On basis of the compressive strength and water absorption test results obtained for both conventional and recycled, the following conclusions can be drawn:

- The concrete strengths for both conventional cement concrete and recycled concrete mixes, it was observed that conventional cement concrete has greater results as compared to recycled cement concrete but also the strength for recycled cement concrete is good as they are greater than target mean strength designed.
- Although the compressive strength of recycled cement concrete (using coarse and fine aggregates) is lesser than that of conventional cement concrete, recycled concrete should be used in light building structures and any other structures which do not require concrete with high strength.

- The water absorption test results for conventional cement concrete was less than that of recycled cement concrete (using recycled coarse and fine aggregates).
- As some construction industries use illegally swamps and landfills as the damping sites which can cause different impacts on the environment and result into the biodiversity degradation, decreasing agriculture harvest (economic crisis) and also reducing new project sites. So, Civil Engineers can work together with researchers so that demolished concrete material should be reused in new concrete production especially for light weight building structures. This will decrease a lot on the problems caused by demolished construction wastes to the environment in general.

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