Analyzing the Compressive Strength of Concrete Cylinder Made from Natural and Recycled Coarse Aggregate

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

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We hereby declare that the work performed in this thesis for the achievement of the degree of Bachelor of Science in Civil Engineering is **"Analyzing the Compressive Strength of Concrete Made from Natural and Recycled Coarse Aggregate"**. The whole work is carried out by authors under the guidance and strict supervision of Dewan Tanvir Ahammed, Lecturer of the Department of Civil Engineering at Sonargaon University (SU), Dhaka, Bangladesh.

It is also being declared that the work performed in this thesis has not been submitted and will not be submitted, either in part or in full for the award of any other degree in this institute or any other institute or university.

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to

''TO OUR PARENTS, FAMILY AND TEACHERS''

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ABSTRACT

Large amounts of garbage are currently being dumped in landfills all over the world as a result of the world's fast industrialization, and as everyone is aware, concrete is one of the most commonly used materials worldwide after water. Every year, more garbage from construction is produced. The current study assesses the overall advantages of recycled aggregate materials made from diverse sources of building and demolition debris. Basic laboratory work on the behavior of concrete materials is included in investigations. These experiments examine the fundamental characteristics of recycled aggregate materials, which can predict how well the material would function in place of natural aggregate materials. Construction is currently generating a lot of construction and garbage in modern Bangladesh. It has been utilized to replace natural aggregate materials with recycled aggregate materials up to a maximum of 100%. The engineering project's conditions and goals have a significant impact on the replacement rate. We used recycled coarse aggregate from concrete that had been crushed for this research project. The majority of the volume of concrete is made up of coarse aggregate. The best way to lessen the quantity of concrete waste that ends up in landfills is to recycle coarse aggregate (RCA). The primary goal of this research project is to examine the compressive strength of recycled coarse aggregate concrete and natural coarse aggregate concrete.

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CHAPTER 1
INTRODUCTION

1.1 Background of the Study

This study is an effort to investigate recycled concrete as a material of hope for the twenty-first century amid increased awareness on the protection of the environment and conservation of natural resources. Several foreign components, including different types of coatings, cladding materials, lumber, soil, steel, hardware, woods, and plastics are directly or indirectly related to the demolished debris taken from a building that is mostly built of concrete. Using the proper mechanical tools such as jaw crushers, impact crushers, swing hammer crushers, etc. The process of removing impurities and crushing rubble into a suitable and acceptable aggregate particle size can be completed continuously and sequentially. The demolished waste can be processed using any one of three methods: dry, wet, or thermal either separately or in combination. It is occasionally advised to use pre-soaked aggregates for the manufacturing of recycled aggregate due to the significant water absorption of recycled aggregate. (Hansen, 1992)

Discovered that, on the basis of an equal slump, recycled aggregate concrete containing both coarse and fine recycled aggregate required 14% more water than control concretes containing unrecycled sand and gravel. When coarse recycled concrete was used to generate the increase in water demand was just 6% for aggregate and natural sand. When comparing the power and economies of conventional and recycled concrete with partial cement and fine aggregate replacement. The recycled concrete attained a compressive strength of up to 77% and a splitting strength of above 90% tensile and flexural strength, as well as a 15% cost reduction

These show that C and D wastes have the potential to be valuable building materials from a technical, environmental, and financial standpoint. When it comes to strength, concrete made using these aggregates falls short of concrete made with natural aggregates. With the extra advantage of having substantially lower density values, concrete yet has a strength that would make it suitable for some applications. This makes it ideal for circumstances when self-weight is an issue and extremely high fire resistance is necessary. In light of these circumstances, the goal of this study was to determine how the partial substitution of fine aggregate with demolition debris affected the workability and compressive strength of recycled concrete over 7 day timeframe. (Srivastava, 2012)

1.2 Research Objectives

- ✓ To observe the compressive strength of recycled & normal concrete using different percentage of recycled aggregate.
- ✓ To compare between compressive strength results for different mixes.
- ✓ To evaluate the feasibility of using recycled aggregate concrete (RAC) as coarse aggregate.

1.3 Organization of the thesis

This thesis consists of five chapter organized as follows:

Chapter 1: Introduction

The introduction is an introductory chapter that provides the reader with the background of the topic, the purpose and scope of the thesis.

Chapter 2: Literature Review

- ✓ This paper reviews the properties of recycled aggregate concrete (RAC), including strength, shrinkage, creep, impermeability. Most of the studies have shown that the long-term properties of RAC are inferior to natural aggregate concrete (NAC).
- ✓ Mortar entrained in aggregate in RAC adds a greater mortar-to-natural aggregate ratio than in NAC. RAC density is always lower than NAC because the mortar has a larger pore size and lower density than natural aggregate.

Chapter 3: Methodology.

This is shown in the experimental method of this thesis. This chapter will introduce the basic characteristics of recycled aggregates, concrete mix proportions and test methods.

Chapter 4: Results and Discussion.

This chapter presents general results and discussion of research on recycled coarse aggregate (RCA) and natural coarse aggregate (NCA).

Chapter 5: Conclusions and Future Work.

This Chapter presents the conclusions and recommendations for further work on Research.

CHAPTER 2
Literature Review

2.1 Introduction

The need for facilities is rising along with the global population, which in turn necessitates the use of limited natural resources. Due to government backing and restrictions, numerous sectors are increasingly exploring for ways to reuse resources in the creation of new goods. The construction sector is no different and has been using this approach for a number of years. Bricks and other materials rescued from the wreckage of war were used for the reconstruction of amenities, which is when recycling of building materials began in Europe and other developed nations around the end of World War II. Recycling, however, as a strategy for resource sustainability didn't really take off until recently in Asia. Reusing construction and demolition (C&D) waste in the construction sector is getting more and more crucial every day for a variety of reasons. The main causes of the rising interest in recycling C&D waste, in addition to environmental protection, include the preservation of natural aggregate resources, a lack of land for garbage disposal, and the rising expense of waste treatment before disposal.

Among the inert C&D Waste, the concrete rubble has the largest proportion and hence its recycling is most important. Many laboratory and field studies have shown that the size fraction of the concrete rubble corresponding to coarse aggregate can be satisfactorily used as a substitute for natural aggregate and the recycled concrete aggregate shows that the later would give at-least two third of the compressive strength and the elastic modulus of the natural aggregate. On the other hand, there are some drawbacks in using recycled aggregates: for example, they have to be separated from other demolition debris before use, and special care is necessary to ensure they are not contaminated. Consequently a lot of potentially useful material is placed in landfills. However, many countries increasingly concern with environmental protection and sustainable development, are introducing legislation and policy measure to encourage the use of recycled aggregates. The incentive to the construction industry often comes in the form of higher landfill costs, and therefore more inspiration towards the production of recycled aggregates. This policy is particularly well established in the Netherlands and the Copenhagen district of Denmark; both of these areas now recycle over 80% of their demolition waste (Collins, 1996). In recent years certain countries have considered the reutilization of construction and demolition waste as a new construction material as being one of the main objectives with respect to sustainable construction activities. This thesis focuses on recycling of C&D waste as an aggregate in structural concrete. From the mid-70s, many researchers have dedicated their work to describe the properties of these kinds of aggregates, the minimum requirements for their utilization in concrete and the properties of concrete made with recycled aggregates. However, minor attention has been paid to both reuse recycled aggregate in structural concrete and the durability of recycled aggregate concretes.

Precast concrete products are cured differently than conventional concrete products. Precast concrete typically uses steam curing because it has a faster rate of strength development. The qualities of the resultant concrete are altered by this curing process, though. It was discovered that compared to conventionally moist-cured concrete, steam curing significantly reduced the creep of concrete by up to 50%. Although there is a wealth of knowledge on how steam curing affects the properties of conventional concrete, there is less information on steam cured recycled aggregate 4 concrete. The impact of steam curing on the tensile strength and durability of concrete made with significant amounts of recycled aggregates needs to be better understood. (Shicong, 2006).

2.2 Background

Recycled aggregates are produced from reprocessing old or used concrete with the largest source being construction, renovation, and demolition waste. During this process of crushing, desired aggregate size can be obtained. The concerns about the physical and mechanical properties have limited the use of the recycled aggregates to specific applications.

An estimated 95 million metric tons of concrete are recycled each year in the United States. Approximately 68% of the recycled concrete is used as a road base, while the remainder is used for new concrete mixes (6%), asphalt hot mixes (9%), high volume riprap (3%), low value products like general fill (7%), and others (7%). However, many State Departments of Transportation (DOTs) either specify a limited spectrum of applications for Recycled Aggregates (RA) in concrete or do not allow its use in concrete at all. These limitations are influenced by the perceived variation in quality and the lack of available acceptance criteria of the recycled aggregate.

Many research efforts have demonstrated an inverse relationship between the amount of RA used and the quality of the new concrete mix. Durability, porosity, and mechanical properties of concrete made with recycled aggregate were affected by the percentage of recycled aggregate used. Results indicated that 50% recycled aggregates content was the optimum amount that can be used in a concrete mix for structural applications to meet specific mix requirements. The experimental results presented in this paper discuss the effect of absorption capacity and effect of using admixtures on strength of concrete produced with different recycled aggregates. (Abdelfatah, 2011).

2.3 Cement

Portland cement is obtained by heating limestone and clay or other silicate mixtures at high temperatures (>1500°C) in a rotating kiln. The resulting clinker, when cooled, is mixed with gypsum (calcium sulfate) and ground to a highly uniform fine powder. Anhydrous Portland cement consists mainly of lime (CaO), silica (SiO2), and alumina (Al2O3), in addition to small amounts of magnesia (MgO), ferric oxide (Fe2O3), sulfur trioxide (SO3), and other oxides that are added as impurities in the raw materials during its manufacture. When these oxides are blended together, they form the four basic components of Portland cement, namely: tricalcium silicate, dicalcium silicate, tricalcium aluminate, and tetracalcium aluminoferrite. Table 2.1 describes the main oxide compositions and abbreviations, in addition to listing the average of each in commercially available ordinary Portland cement (OPC) (wt.%). (Hosam M. Saleh, 2020)

Table 2.1: *The Main Oxide Compositions and abbreviations in addition to the average of each in commercially available Portland cement.*

CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	Na_2O	K_2O	Loss	Insoluble
63.50	21.86	5.90	3.20	1.80	1.70	0.2	0.7	1.24	0.50

Figure-2.1: *Cement* (Concrete Network, 2022)

2.3.1 Concrete

Recycled concrete aggregate (RCA)

The use of RCA in Ontario is gaining acceptance as more performance information is becoming available and political pressure to use less natural aggregate is increasing. Organizations such as Aggregate Recycling Ontario, which advocate for the use of RCA have begun to affect some change in the practices of municipalities throughout Ontario. Recently Bill 56 has been proposed to the Legislative Assembly of Ontario. The bill aims to prohibit the practice of limiting public sector construction projects to virgin materials. Previous practice has allowed for bids proposing the use of recycled material to be rejected based on this fact. The bill has been carried through the first and second readings in the house and has been referred to the standing committee on Finance and Economic Affairs (Assembly, 2013).

The most common practices for RCA use in Ontario involve placement of RCA as a fill type material. This includes use as granular base and sub-base for pavements, trench backfill material, engineered fill, stabilization of soft sub grades, fill under concrete slab-on-grade, and pavement shoulder construction.

In 2007, it was estimated that approximately 13 million tons of RCA was used in Ontario. This corresponds to about 7% of the total aggregate used in that year. Most of this RCA was used in the construction of roadways as outlined previously (MNR, 2010). There is currently no widespread use of RCA in the production of concrete in Ontario.

RCA is a material that has a large potential supply which currently outstrips its demand. This potential supply consists of every existing concrete structure that will eventually be demolished. One of the prominent issues associated with this large supply however is that each concrete structure is composed of different materials. These differences depend on factors such as structural requirements, available materials, the year in which the concrete was produced, and many others. This wide variation in concrete composition results in a similar variation in the RCA, which is produced when the concrete is crushed. The wide variation in RCA results in some materials with intrinsic properties that lend themselves well to the production of high quality concrete and other materials, which could 6 be detrimental to the performance of any concrete. Between these two extreme RCA types exists a wide spectrum of RCAs that perform variably in concrete.

While some of the RCAs on this spectrum may not be feasible for use in concrete, they are often found to be acceptable for use as granular material in fill or base applications.

The inherent variability of RCA causes concern amongst concrete producers and specifies in Canada, which often results in avoiding the use of RCA completely or to limiting its use to lean concrete or other similar low-demand applications. Given the findings of this previous research, limiting the use of RCA is often considered as a reasonable way to limit the risk associated with the material.

Some RCAs have been found to have properties that are not detrimental to concrete production or performance when incorporated. In these cases, the practice of avoiding the use of RCA results in the loss of significant potential value, in terms of available construction materials.

Previous research performed at the University of Waterloo produced an RCA classification framework that served to classify different RCAs according to their best potential use or application. These applications ranged from use in reinforced structural concrete to use only as a fill material. The framework was developed such that classification depended largely on aggregate tests. This allows for classification to be performed without knowledge of RCA"s source concrete, since this information is often unknown for a given RCA. The framework developed is an excellent step towards the development of a widely source-inclusive tool that could be used industry-wide to achieve much more effective use of existing and future RCAs (Butler, 2013).

According to the classification framework developed through previous research at the University of Waterloo, RCA1 was classified as Class A1 (or Class A2), and RCA2 was classified as C. This implies that RCA1 is "high quality" material and would be suitable for use in structural and nonstructural concrete applications. Conversely, RCA2 would be considered "low-grade" material and would be suitable only for use in structural and non-structural fill applications (Butler, 2013) (Pickel, 2014).

2.3.2 Coarse Aggregate

The coarse aggregate was created in accordance with the mix type that was provided. Fully saturated coarse aggregate, slightly saturated coarse aggregate, and oven-dry coarse aggregate were among the mix types. To determine the real water content of each mixture, a water content sample was collected in each case after the saturation process. (Pickel, 2014)

Figure-2.2: *Coarse Aggregate* (D Poornima, 2017)

2.3.3 Fine Aggregate

In the experimental program, natural sand that was obtained locally was employed. Fine aggregate that has been deposited by streams or glaciers and is the consequence of the natural breakdown of rocks (Pickel, 2014).

Figure-2.3: *Fine Aggregate* (Google and DH Infra)

2.3.4 Function of Aggregate in Concrete

Functions of Fine Aggregate in Concrete

Fine aggregates perform the following functions:

- ✓ It assists in producing workability and uniformly in mixture.
- ✓ It assists the cement paste to hard the coarse aggregate particles.

- ✓ It helps to prevent possible segregation of paste and coarse aggregate particularly during the transport operation of concrete for a long distance.
- ✓ Fine aggregate reduces the shrinkage of binding material.
- ✓ It prevents the development of a crack in the concrete. (Sautya, 2019)

Functions of Coarse Aggregate in Concrete

Coarse aggregate is used in concrete to achieve the following functions:

- ✓ It makes a solid & hard mass of concrete with cement and sand.
- ✓ It provides bulk to the concrete.
- ✓ It increases the crushing strength of concrete.
- ✓ It reduces the cost of concrete by using cheaper material. (Sautya, 2019)

2.3.5 Function of water in Concrete

The goal of this study is to characterize concrete performance under extreme triaxle loadings (such as impacts from ballistic or near-field explosions). Static tests using a very high-capacity triaxle press have been conducted on concrete samples to replicate high stress levels with carefully regulated loading routes (stress levels on the order of 1 GPa). The porosity and strength of the cement matrix of cured concrete are significantly influenced by the water/cement ratio (W/C), which enters the concrete mix. This article's goal is to measure this ratio's impact on specific behavior under very constricted circumstances. Two further concretes have been created from the ingredients of a reference "ordinary" concrete (W/C=0.6) with W/C ratios of 0.4 and 0.8, respectively. In this article, the effects of the water/cement ratio (W/C) on the behavior of concrete under high confinement are examined through experimental findings and their analysis. It demonstrates how concrete behaves as a granular stack of concrete while under high confinement without being affected by the degree of cement matrix strength. (John Wiley & Sons, 2009).

Water cement ratio refers to the ratio of the weight of cement to the weight of water applied to the concrete mix.

Generally, the water cement ratio is below 0.4 to 0.6 as per IS Code 10262 (2009). For nominal mixes (M10, M15 .... M25)

The strength of concrete is directly affected by the water cement ratio. It increases power if employed in perfect proportion and decreases power if proportion is improper.

2.3.6 Classification of Concrete

The criteria used to classify concrete most frequently are as follows:

- ✓ Concrete mixing specifications
- ✓ Bulk density of the concrete
- ✓ The type of binder
- ✓ The consistency of the fresh concrete
- ✓ Concrete class
- ✓ The purposes of concrete and other. (BIS)

2.3.7.1 Strength of Concrete

Type of Concrete Strength:

1. Compressive Strength:

Specimen's compressive strength Results from common treatments, such as complete compaction and wet curing for a predetermined amount of time, reflect the prospective quality of the concrete. The compressive test involves three different forms of loading:

A. uniaxial loading

B. biaxial loading

C. triaxle loading

There are three types of failure

A. tension failure

B. shear failure

C. companied failure.

2. Tensile Strength:

The direct measurement of tension under axial loading cannot be done in the field. The test is challenging to conduct, and the outcomes are unreliable. However, there is an indirect technique known as the splitting tensile test that involves loading a typical test cylinder in compression while it is on its side.

In most cases, flexure, torsion, or a mixture of loadings are used to apply tensile stresses to the concrete in the structure rather than pure tension. The impact of tension on the regulation of cracking has raised awareness of the significance of tensile strength, nevertheless. According to research, direct tension typically accounts for 10% of the compressive force and can reach up to 20% for high-strength concrete (8000–10,000 psi compressive).

2.3.7.2Durability of Concrete

The level of exposure, concrete grade (or strength), and cement content all affect how long concrete will last. An alkali-resistant concrete with a high density will be more resilient to the effects of moisture infiltration. Because concrete is a porous substance, reinforcement bars inside the concrete may corrode if precautions are not taken. In order to prevent moisture or salt from infiltrating the reinforcement, adequate concrete "cover" for the rebar should be specified. The concrete will crack if the rebar corrodes because it will expand under the strong stresses involved. (Dr C.R. Bayliss Eng FIET, 2012)

2.5 Properties of Recycled Coarse Aggregate

Utilizing recycled aggregate made from leftover concrete as part of a fresh concrete mix necessitates a full grasp of its fundamental characteristics, as some of them may be very different from those of aggregates made from natural resources. Additionally, the distinctions between them are mostly based on the quantity and caliber of cement mortar which is used to bind the recycled aggregate grains, followed by the caliber of the original concrete from which the recycled aggregate is created and the recycling techniques. However, the uneven quality, or changes in the qualities of recycled aggregate, are considerably more noticeable than they are with natural aggregates when the recycled aggregate comes from a variety of sources. (Malešev, 2014)

2.5.1 Importance of W/C Ratio

When part of the Portland cement has been substituted with a supplementary cementitious material or filler, this new cementing system can be characterized by two ratios: its w/c and w/b ratios. Which one of these two ratios is more useful in characterizing the system? The answer is both: the w/c ratio is not passé (Barton, 1989). In the short term, the early mechanical properties are linked primarily to the w/c ratio, because the first hydrates that give the cement paste its strength are the ones that develop on the surface of the cement particles; supplementary cementitious materials and fillers are not as reactive as Portland cement particles and their reactivity depends on their type. Very roughly, it can be assumed that silica fume begins to react significantly within the first 3 days, slag within the first 28 days, and fly ash within the first 56e91 days following the casting of concrete, and filler never. However, the initial network of capillaries of the cement paste is generally governed by the w/b ratio and no longer by the w/c ratio. Therefore, the w/b ratio will determine the size of the menisci that form in the cement paste as a consequence of the chemical contraction that is observed when Portland cement hydrates in the absence of an external source of water, as will be seen in the following chapter. In the long term, the w/b ratio also influences the compressive strength and durability of cement pastes made with blended cements containing supplementary cementitious materials.

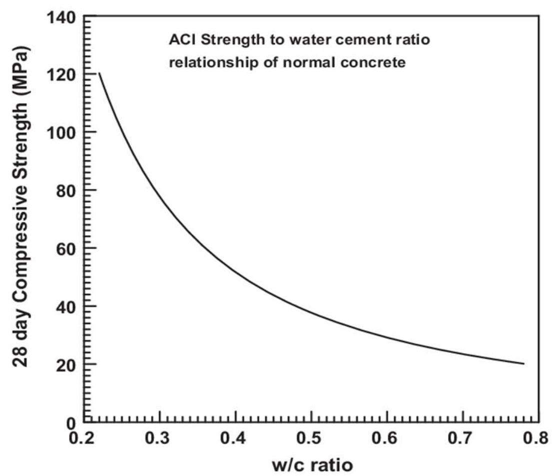

Figure- 2.4: *Strength & w/c ratio* (Manu S Nadesan, 2014)

2.6 Summary

RCA are created in stationary recycling facilities similar to those that create naturally crushed aggregate. Processing typically involves removing impurities, screening, and two stages of crushing (mainly with jaw crushers and secondarily with impact crushers). Large electro-magnets are used to extract the remaining reinforcement after primary crushing. All impurities must be meticulously removed using water washing or air sifting, including dirt, plaster, gypsum, and other building waste. Mobile recycling facilities are another option for processing RCA. These are frequently employed in demolition sites where there is a lot of homogenous garbage that will be recycled on the premises (e.g., rebuilding of roads and highways, large industrial facilities). Processing in mobile recycling plants is restricted to one-stage magnetic separation, screening, and crushing.

By reducing wastes, conserving landfill space, and recycling demolished concrete into aggregate, concrete recycling is good for the environment. However, the recycling procedure itself as well as a potential increase in cement usage in RCA structural concrete lead to significant environmental burdens (Weil et al., 2006; Marinković et al., 2017).

CHAPTER 3
Methodology

3.1.1 Cement

A binder or substance that sets, hardens and clings to other materials to bind them together, is referred to as cement in the building industry. In most cases, cement is used to bond sand and gravel (aggregate), not on its own. Mortar for masonry is made from cement mixed with fine aggregate, and concrete is made from cement combined with sand and gravel. The second most utilized resource on the globe after water is concrete, which is the most often used substance in existence. The majority of cements used in building are inorganic, frequently made of lime or calcium silicate, and are classified as either non-hydraulic or hydraulic based on their propensity to set in the presence of water. In moist conditions or when submerged in water, non-hydraulic cement does not set. After setting, it is resistant to chemical attack. A chemical reaction between the dry materials and the water causes hydraulic cements Portland cement to set and become sticky. Mineral hydrates, which are formed as a result of the chemical reaction and are not particularly water soluble, are quite durable in water and resistant to chemical attack. This makes it possible to set in damp environments or under water and further shields the material against chemical attack. Ancient Romans discovered the chemical method for hydraulic cement using lime-added volcanic ash (calcium oxide).

Figure-3.1: *Cement*

3.1.2 Fine Aggregate

Fine aggregates are basically natural sand particles from the land through the mining process, the fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller. This product is often referred to as ¼'' minus as it refers to the size or grading of this particular aggregate. Aggregates less than 4.75 mm in size are called fine aggregates sand falls under the fine aggregate and crushed stone or metal under the coarse aggregates.

Figure-3.2: *Sand*

3.1.3 Natural Coarse aggregates

Brick chips were used as Natural coarse aggregate.

Figure-3.3: *Natural Coarse aggregates*

3.1.4 Recycled Aggregates

The term Recycled coarse aggregate is used for reusing the coarse aggregates which already used by crushing concrete collected from construction debris. It is very sustainable option to use recycled materials in the construction field. Through recycling we can reduce or prevent the collection of materials for buildings, many other infrastructure projects. Simultaneously we can also reduce or prevent the construction debris or construction refusal from entering into landfills. The whole process of recycling can be done at the construction demolition site or can be done at permanent facility with easy process.

Figure-3.4: *Recycle Coarse aggregates*

3.2 Concrete Mix Proportion

For this research mixture proportion are as bellows

- ✓ water/cement ratio 0.55
- ✓ Same maximum grain size (20mm)
- ✓ Same type and quantity of fine aggregate
- ✓ Variable type and quantity of coarse aggregate.
- ✓ Mixing ratio 1:1.5:3.

3.3 Mixing of Concrete and Molding

For concrete to be consolidated by vibration, fill the mold in two equal layers. Place the concrete in the mold by distributing it around the inside of the mold with the scoop. Consolidate the layer by rodding 25 times evenly distributed around the layer.

Figure-3.5: *Mold of Cylinder.*

3.4.1 Demolding

According to BNBC, after 24 hours of casting, the concrete samples were removed from the mold and allowed for curing.

3.4.2 Curing

After demolding, the specimens were placed under water up to 7 days. The samples were fully submerged under water.

Figure 3.6: *Curing of concrete specimens*

Total number of specimens for each test and their age and size are given below:

Table 3.1: *Specifications of the property, the test technique, the age at test, and the quantity and size of specimens*

Name of Test	Test Method	Ages (Days)	Size of Specimens	No. of Specimens
Compressive Strength	ASTM C39	7	100 mm dia × 200 mm height Cylinders	9

3.5 Compressive Strength Test

For compression test, cylindrical mold of size (100 mm dia × 200 mm height Cylinders) were prepared and were tested in CTM (compression testing machine) as per ASTM C39, These concrete samples were tested at 7 days for strength estimation.

In this method, axial compressive load is applied to the cylinder specimen at a standard load rate the machine can provide. Load is applied until the failure occurs. The strength test can be used for quality control acceptance of concrete to use in construction.

3.6 Apparatus

- ✓ Compression testing machine and
- ✓ Balance.

Figure 3.7: *Compressive Strength Test Machine*

CHAPTER 4

Results and Discussion

4.1 Introduction

Compressive strength refers to the strength of hardened concrete when measured by a compression test, which entails crushing cylindrical concrete in a compression testing machine. It tests the capacity of concrete to withstand a load before experiencing failure. Concrete has been made with different percentage of coarse aggregate and Recycled Coarse Aggregate from different sources for target strength. OPC & Coarse sand were used as fine aggregate to make the concrete. Compressive strength has been tested for 7 days.

4.1.1 Sieve Analysis of Sand

Sieve analysis of fine aggregates is one of the most important tests performed on-site. Aggregates are inert materials that are mixed with binding materials such as cement or lime for the manufacturing of concrete. It is also used as filters in mortar and concrete. The standard size sieves are 3/4 (19.0 mm), 3/8 (9.5 mm), No. 4 (4.75 mm), No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (600 µm), No. 50 (300µm), and No. 100 (150 µm). It is used for the purpose of estimating the quantity of coarse aggregate to be used in the concrete mix design.

Table 4.1: *Result of Sieve Analysis of Sand*

Sieve No.	Retain(gm)	% of Retain (gm)	Cumulative % Retain	% Finer	F.M.
#4 (4.75 mm)	0	0	0	100	306.85/100 =3.07
#8 (2.36 mm)	48	5.98	5.98	94.02	
#16(1.19 mm)	248	30.88	36.86	63.14	
#30 (0.59mm)	280	34.87	71.73	28.27	
#50 (0.30mm)	172	21.42	93.15	6.85	
#100 (0.15mm)	48	5.98	99.13	0.87	
Pan	7				
Total = 803 gm			Total=306.85		

4.1.2 Sieve Analysis of Natural Coarse Aggregate

Table 4.2: *Sieve Analysis of Natural Coarse Aggregate*

Sieve No	Retain(gm)	% of Retain (gm)	Cumulative % Retain	% Finer	F.M.
#3/4"(19.05mm)	550	55.61	55.61	44.39	752.88/100 =7.53
#3/8"(9.52mm)	412	41.66	97.27	2.73	
#4(4.75mm)	27	2.73	100	0	
#8(2.36mm)	0		100	0	
#16(1.19mm)	0		100	0	
#30(.59mm)	0		100	0	
#50(.33mm)	0		100	0	
#100 (0.15mm)	0		100	0	
Pan	2				
Total = 989 gm			Total=752.88		

4.1.3 Sieve Analysis of Recycle Coarse Aggregate

Table 4.3: *Sieve Analysis of Recycle Coarse Aggregate*

Sieve No	Retain(gm)	% of Retain (gm)	Cumulative % Retain	% Finer	F.M.
#3/4"(19.05mm)	854	71.70	71.70	28.30	769.93/100 =7.70
#3/8"(9.52mm)	316	26.53	98.23	1.77	
#4(4.75mm)	21	1.76	100	0	
#8(2.36mm)	0		100	0	
#16(1.19mm)	0		100	0	
#30(.59mm)	0		100	0	
#50(.33mm)	0		100	0	

#100 (0.15mm)	0		100	0	
Pan	2				
Total = 1191 gm			Total=769.93		

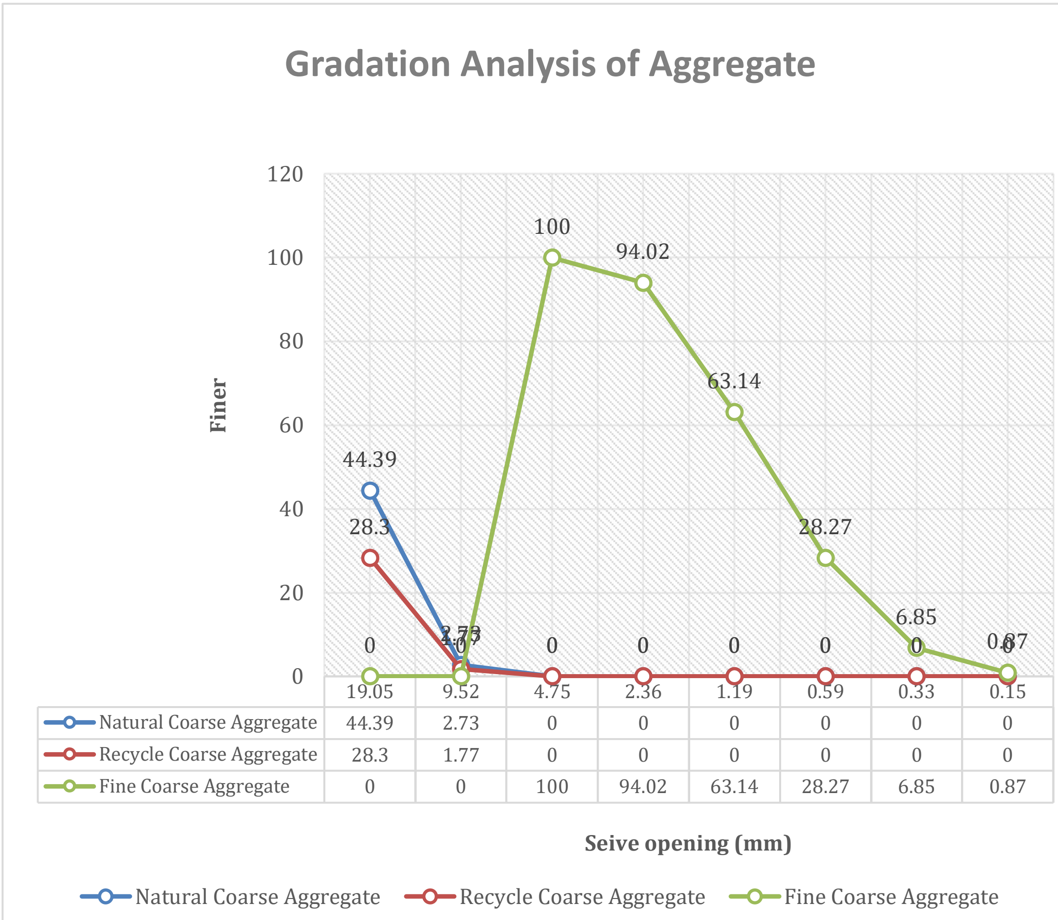

Figure: 4.1 *Gradation analysis of aggregate*

The figure 4.1 shows three different types of aggregates. These are fine aggregate, recycled aggregate and natural aggregate. For fine aggregate we use 4.75 mm, 2.36 mm, 1.19 mm, 0.59 micrometer, 0.33 micrometer and 0.15 micrometer. In sieve analysis, fine aggregate retains 100%, 94.02%, 63.15%, 28.27%, 6.85%, 0.87% respectively. use 19.05 mm, 9.52 mm, 4.75 mm, 2.36 mm, 1.19 mm, 0.59 micrometer, 0.30 micrometer, 0.15 micrometer for recycled aggregate and natural aggregate. In sieve analysis, material retains 28.3%, 1.77%, 0%, 0%, 0%, 0%, 0%, 0% for recycled aggregate and in case of natural aggregate material retains 44.39%, 2.73%, 0%, 0%, 0%, 0%, 0%, 0% respectively. In sieve analysis we have also calculated cumulative % retain and % finer (percent of material passing).

4.2 Strength Test

4.2.1 Compressive Strength Test Results for Varying Mixes

Compressive strength refers to the ability of a certain material or structural element to withstand loads that reduce the size of that material or structural element, when applied. The compressive strength of cylinder was determined with the help of compression testing machine (CTM). Table 4.3 gives the result of compressive strength of concrete of both natural and recycled concrete at the age of 7 days.

Table 4.4: *Compressive Strength Test 7 days*

M20 Grade Concrete	% of Recycle Coarse Aggregate	No. of Cubes	Compression Strength (in PSI)	Average Compression Strength (in PSI)	Result (in PSI)
Natural Coarse Aggregate Concrete	0%	1	2146	2247	2247
		2	2235		
		3	2361		
Recycled Coarse Aggregate Concrete	100%	1	1610	1610	1610
		2	1484		
		3	1735		
Natural Coarse Aggregate Concrete & Recycled Coarse Aggregate Concrete	50% + 50%	1	1914	1938	1938
		2	2057		
		3	1842		

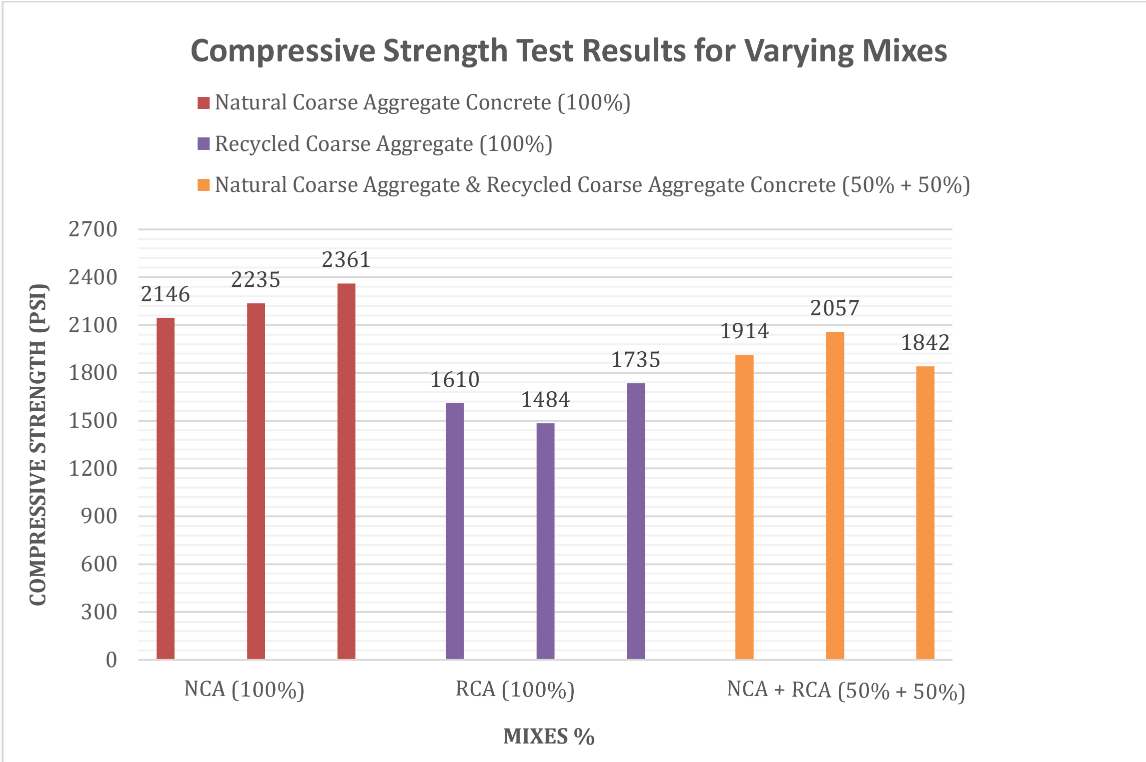

Figure-4.2: *Compressive strength test results for varying mixes.*

The figure 4.2 shows, maximum compressive strength 2361 Psi for 100% Natural aggregate mixing for 7 days as well as maximum compressive strength 2057 Psi for 50% recycled concrete aggregate mixing for 7 days. The minimum value of compressive strength at same duration is 1735 Psi with 100% recycled concrete aggregate mixing.

CHAPTER 5

Conclusions and Future Works

5.1 General

This research presents specific examples of strength development properties for various gross percentages. The goal of these studies is to enhance the development of concrete structures.

5.2 Conclusions

The experiment is a component of a larger program that includes experimental examinations to determine the impact of replacing some of the coarse aggregate in concrete with various percentages of recycled aggregate on the concrete's compressive strength over a period of seven days.

Compressive strength achieved by concrete at 7 days is about 65% of total gain after 28 days (ASTM C39/C39M). Our mix proportion is 1:1.5:3 and for this ratio specific compressive strength 3000 psi after 28 days comparing with this after 7 days compressive strength 1950 psi which is higher than 1610 psi average compressive strength of 100% recycled coarse aggregate concrete. Based on this study, we can use recycled coarse aggregate replace of natural coarse aggregate where our target value is like this. Concrete is strongest when the quantity of water mixed into it is just sufficient to react with the cement. Any excess water which is not absorbed by the cement will make the final concrete weaker. For this we can use super plasticizer to get our anticipated level of workability.

The outcome of this research is that RCA replacement at 50% is the cost-effective option, thus we employ it in moderately loaded structures or other places where there is a low probability of additional load. Strength and density both decrease with an increase in the percentage of RCA replacement.

By bringing construction and demolition waste into the production line, we can reduce its negative impact on the environment and help save costs. To get high strength concrete we have to make sure that we use good quality coarse aggregate, high strength concrete using waste recycled aggregate will give high strength concrete.

REFERENCES

Abdelfatah A, S. T. *Journal of civil Engineering and Architecture*, 562-563. ASCO-TP. (2011).

Assembly, L. Aggregate Recycling Promotion Act, 2013. Retrieved September 29, 2013, from Legislative Assembly of Ontario: (2013).

ASTM, A. S. Significance of Tests and Properties of Concrete and Concrete-Making Materials. (2006).

BIS. (n.d.). *Bentonska Industrija Srbija*. Classification of concrete.

Butler, L.T. Guidelines for the Selection and Use of Recycled Concrete Aggregates in Structural Concrete *Journal of the Transportation Research Board*, 3-12. (2013).

Collins, R. Increasing the Use of Recycled Aggregates in Construction Proceedings of the International Conference: Concrete for Environment Enhancement and Protection, Dundee Scotland, Increasing the Use of Recycled Aggregates in Construction Proceedings of the International Conference: Concrete for Environment Enhancement and Protection, Dundee Scotland,, 73-80. (1996).

Dr C.R. Bayliss Eng FIET. Transmission and Distribution Electrical Engineering. (2012).

Dr. M.N.Bajad, N. M. Effect of Recycled Aggregate and Fly Ash in Concrete. p. 29, (2015).

Dr.M.Aaziz. A Text Book of Engineering Materials. University Campus. (2nd Edition, 2019).

Hansen, T. a. Strength of recycled concrete made from coarse and fine recycled concrete aggregate. 135. (1992).

Hosam M. Saleh, Samir B. Eskander, in New Materials in Civil Engineering, (2020).

Krishna. Important Properties of Concrete, 1. (2018).

Krishna. Curing of Concrete | Curing time & Duration | Curing methods. (2020).

Malešev, M. Properties of Recycled Aggregate Concrete p. 240. (2014).

MNR. State of the Aggregate Resource in Ontario Study. Ontario Ministry of Natural Resources. (February 2010)

Pickel, D. Recycled Concrete Aggregate: Influence of Aggregate pre-saturation and curing conditionson the hardened properties of concrete. Watweloo,Ontario,Canada. Powers. (2014) (1968).

Recycling, A. Aggregate Recycling Ontario. (2013).

Rodriguez, J. Ways to Recycle and Reuse Concrete. (2007).

Roy, A. The role of water in concrete. p. 1. (2018).

Sahu, A. (n.d.). Civil Gyan.

Sautya, M. Functions Of Fine and Coarse Aggregate in Concrete. p. 1. (2019).

Shicong, K. Resuing reycled aggregate in structural concrete. Resuing reycled aggregate in structural concrete, p. 3. (2006).

Srivastava, V. Utilization of demolished waste as fine aggregate in Concrete. Utilization of demolished waste as fine aggregate in Concrete. , p. 398. Wagih, A. M. (n.d.). 3. (2012)

D Poornima. "Replacement of Coarse Aggregate by Demolished Brick Waste in Concrete," Trans. Of the ASME, - *International Journal of Science Technology & Engineering*, Vol. 4, Issue 2, (2017)

Google Android, https://www.exportersindia.com/product-detail/brown-construction-sand-5672918.htm [Last accessed on 06 Sep.2022]

P. Dinakar S.N. Manu. "Concrete mix design for high strength self-compacting concrete using metakaolin," *School of Infrastructure, Indian Institute of Technology*, Bhubaneswar 751013, India, 2014.