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PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH DEMOLITION WASTE

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CANDIDATE'S DECLARATION

I, Imran Ali Mansoori Roll No. 2K21/STE/11 of M. Tech Structural Engineering, hereby declare that the project Dissertation titled "Partial Replacement of Coarse Aggregate with Demolition Waste" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for any Degree, Diploma Associateship, Fellowship, or other similar title or recognition.

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CERTIFICATE

I hereby certify that the project Dissertation titled “Partial replacement of Coarse Aggregate with Demolition Waste” which is submitted by Imran Ali Mansoori, Roll No 2K21/STE/11 Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of the requirement for the award of the degree of Master of Technology, is a record of the project carried out by the students under my supervision. To the best of my knowledge, this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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ABSTRACT

In India and other nations, many concrete buildings are destroyed. However, the amount of waste from demolition that gets recycled is minimal. This will cause significant environmental degradation and necessitate a sizable quantity of room for waste disposal. As a result, our idea attempts to reuse concrete from demolished building. We obtained the demolition waste for our study from the Shastri Park, MCD Construction and Demolition Waste Recycling Process Plant owned by Indo Enviro Integrated Solution Limited. Any concrete structure must be built with a lot of natural coarse aggregate. So, it may lower the cost of buying natural coarse aggregate by employing the demolition material. In our study, demolition material will replace the coarse aggregate at different mix proportion of 0%, 10%, 20%, 30%, 40%, 50%, and 100%. The cubes and cylinder were cast using a variety of mix proportions and allowed to cure for 7, and 28 days. After curing, the Split tensile strength, XRD and compressive strengths of concrete cylinders and cubes were examine.

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LIST OF SYMBOLS, ABBREVIATIONS, AND NOMENCLATURE

RCA	Recycle Coarse Aggregate
RCC	Reinforced Concrete Cement
XRF	X-Ray fluorescence
XRD	X-Ray diffraction
OPC	Ordinary Portland Cement
IST	Intial Setting Time
FST	Final Setting Time
M SAND	Manufactured Sand
TIFAC	The Technology Information, Forecasting and Assessment council
FWHM	Full Width at Half Maximum
PC	Polycarboxylate
CTM	Compression Testing Machine
UTM	Universal Testing Machine
RA	Recycle Aggregate

CHAPTER 1

INTRODUCTION

1.1 OVERVIEW

The primary building material now in use is concrete. Concrete is made up of water, fine aggregate, coarse aggregate, and binding ingredient (cement). Aggregates are naturally obtainable but are being over-exploited for development purposes, which causes their availability to diminish day by day. Aggregates won't be readily available in the near future due to rising demand because of their limited stack. It is beneficial to look for alternatives to the naturally occurring aggregate. Demolition waste is created in significant amounts due to increased construction activity and structure renovation, and it is stored in enormous numbers in low-lying areas or at disposal sites. The land that demolition wastes are dumped on is permanently unavailable for further uses. Increased demolition waste production, a persistent lack of dump sites, rising land transportation costs, and most importantly, environmental concerns are all contributing factors.

1.2 BACKGROUND HISTORY

Waste generation is increasing as a result of the accelerated expansion of industry and metropolitan areas, which is detrimental to the environment. There are currently 27.8% more people living in cities in India than there were in 1947, a 13.8% increase. Due to the development of new infrastructure, there is a ($55x10^3$) million m^3 shortfall, which indicates that aggregate demand will rise in the future. To meet the demand of the road sector, an additional 750 million m^3 of aggregate is needed. There is a big imbalance between the supply and demand for aggregates because of the high need for these materials in contemporary building and transportation. Waste produced during construction weighs between 40 and 60 kilogrammes per square metre. The amount of waste produced during remodelling, repair, and maintenance constructions ranges from 40 kg/m^2 to 50 kg/m^2. The most of all material are produced during a building's destruction. About 300 kg/m^2 of waste is produced when permanent buildings are demolished, while 500 kg/m^2 of waste is produced when semi-permanent buildings are demolished.

1.3 RECYCLE AGGREGATE

Aggregates made from previously used building materials like concrete or masonry are known as recycled aggregates. Crushed or powdered inert mineral materials like gravel and sandstone make up recycled aggregates. They are frequently produced during building and demolition projects, including those involving roads, bridges, remodelling, and other projects. The non-biodegradable materials including concrete, plaster, metal, wood, and polymers make up most of the waste created by these activities. Most of this material is often dumped in municipal waste streams. These wastes take up a lot of room in bins or waste cans because of their bulkiness, high density, and weight. Large piles of waste frequently end up on the roads as a result, especially during major construction projects, which causes traffic congestion and disturbance. Small-scale generators of waste, such as one-off home construction or demolition projects, frequently dump their debris into local municipal waste storage depots or bins. The overall weight is increased by this additional waste, which also makes it less suitable for composting or energy recovery. When this garbage enters surface drains, it can occasionally clog them up as well. Except for waste coming from major building projects, small generator waste normally makes up 10 to 20% of municipal solid waste.

These wastes take up a lot of room in dumpsters or by the side of the road because of their bulkiness, weight, and high density. Large and sizable heaps of this waste are frequently seen on streets, especially during big building projects, which causes traffic congestion and in conveniences. Small-scale generators' waste makes its way into local municipal storage depots, bins, or vats, such as individual home construction or demolition projects. This extra waste makes the whole amount heavier and less suitable for further processing, such as composting or energy recovery. This waste, once it enters surface drains, frequently causes repeated obstruction. If waste from sizable construction projects is excluded, it makes up roughly 10 to 20 percent of municipal solid waste.

An estimated 10 to 12 million tonnes of garbage are produced annually in India's construction industry. According to projections, the housing sector needs about 55×10^3

million cubic metres (cu.m) fewer aggregates than are now on hand. To achieve its goals, the road sector would also require an additional 750 million cubic metres of aggregates. Recycling aggregate from demolition and building waste could help balance out the demand and supply in both sectors. However, despite the presence of recyclable materials like bricks, wood, metal, and tiles, concrete and masonry waste, which makes up over 50% of the waste from construction and demolition activities, is not currently recycled in India.

Recycling techniques for concrete and masonry waste are used in nations including the United Kingdom, the United States, France, Denmark, Germany, and Japan. The Technology Information, Forecasting and Assessment Council (TIFAC)'s research, however, found that just 70% of the building sector is aware of these recycling techniques. The report suggests creating standards for recycled aggregate concrete and components in order to remedy this. By enabling manufacturers to produce goods of the desired quality and giving consumers the assurance of a minimum standard, this would promote consumer adoption.

Fig 1.1 Demolition Waste

Fig 1.2 Demolition Waste

1.4 CHARACTERISTICS OF DEMOLITION WASTE

Depending on the particular materials and structures involved, demolition waste can have a variety of different properties. Nevertheless, some typical traits of demolition waste include:

1. Demolition waste often consists of a variety of materials, including concrete, bricks, wood, metal, plaster, glass, plastics, and other building supplies.
2. Due to the size and composition of the materials used, such as concrete blocks, beams, and major structural components, demolition materials can be bulky and take up a lot of room.
3. Non-biodegradable: A large portion of demolition waste is made up of non-biodegradable materials including plastic, metal, and concrete that do not break down over time.
4. Contamination: Particularly in older buildings, demolition waste may contain contaminants like asbestos, lead-based paint, or dangerous chemicals. In order to prevent environmental and health problems, these contaminants must be handled and disposed of properly.
5. Concrete and metal are two examples of materials that can be heavy and dense and contribute to the weight and volume of demolition waste.
6. Recoverable Materials: Despite its varied composition, demolition waste frequently contains salvageable components that can be recycled or utilised again in different manufacturing or construction processes, such as wood, metal, and bricks.
7. Potential for Hazardous Waste: Debris from demolished structures could also contain hazardous waste, such as chemicals, batteries, or electrical parts, which calls for specific management and disposal techniques.

It's crucial to remember that different nations and regions may have different rules and procedures for handling and managing demolition waste materials. To reduce the negative effects on the environment and maximise the recovery of valuable materials from demolition waste, proper sorting, recycling, and disposal techniques should be used.

1.5 NEED FOR RECYCLED AGGREGATE

1. Natural resources are being depleted at a rapid rate due to urbanisation and population increase.
2. Due to the lack of inexpensive, high-quality aggregates that are readily available, the building sector is experiencing difficulties.

3. Expensive compared to recycled aggregates for high-quality crushed aggregates.
4. A significant increase in waste production and a lack of disposal facilities.
5. The price of transportation and disposal have significantly increased as a result of the scarcity of dumping sites.
6. Increased disposal costs result from the need to remove demolished material from construction sites quickly.

1.6 SCOPE OF RECYCLE AGGREGATE

Beyond ordinary levels of waste output, the building industry is expanding quickly over the world. However, this waste can be recycled and changed into useful forms, which has a positive impact on the environment either directly or indirectly. Examples of available recycled aggregates include the following:

1. As the disposal of waste from demolished structures declines, there is more land that is becoming available.
2. When building roads, recycled aggregate can be used as fill material.
3. Rigid pavements can be built effectively using recycled aggregate.
4. Ballast for railroads can be made from recycled aggregates.
5. Natural aggregate can be replaced with recycled aggregate, which has superior properties.

1.7 SOURCE OF RECYCLE AGGREGATE

1. Conflict-related damage, disaster-related construction waste, demolition-related waste, and the replacement of existing buildings with new ones for future development are all examples of damage.
2. Pavement crushed from Portland concrete.
3. lab specimens that were tested.
4. Using ready-mix concrete factories and pre casting facilities, concrete is produced.
5. Deteriorated rail ballast

1.8 PRODUCTION OF RECYCLE AGGREGATE

a. RECYCLING PROCESS

Long boom arm mechanical hydraulic crusher: The concrete and steel reinforcing are broken down by the crushers using a long boom arm equipment.

Fig 1.3 Long Boom Arm Hydraulic Crusher

Destroying ball: The Destroying ball, which is suspended from a crawler crane, uses its impact energy to destroy the building.

Fig 1.4 Destroying Ball

b. TRANSPORTATION

Buildings and cement pavements are torn down, and the discarded concrete is then processed at recycling plants. The building and demolition materials are transported using roll-off containers and dump body trailers since they are economical and effective. Closed box trucks and covered containers are frequently used for this.

Fig 1.5 The Roll-off Container

c. CRUSHING PLANT

The first step in turning construction and demolition waste into repurposed material is crushing. In this procedure, fragments of the concrete waste are crushed. Jaw crushers or impacting mill crushers are typically the equipment used for the crushing operation. The primary jaw crusher will reduce the concrete waste to a size of around 3 inches. The materials will be crushed to their largest size, which varies between 34 and 2 inches, using the secondary cone crushers. To extract all the scrap metal, magnetic conveyors are installed in every recycling crusher.

Fig 1.6 Load in the Primary Crusher.

d. TECHNIQUES FOR CLEANING AND CLASSIFYING RECYCLABLE AGGREGATE

Electromagnetic separation

In the primary and secondary crushers, the reinforcing steel is removed using the electromagnetic separation process using a magnet installed across the conveyor belt.

Fig 1.7 Process of Electromagnetic Separation

Dry separation

By blowing air, lighter particles are separated from heavier stony in the dry separation process.

Wet separation

With the help of water jets and a float-sink tank, wet separation is a technique that produces very clean aggregate by removing low density contaminants.

Fig 1.8 Process of Wet Separation

Hand-picking is an option for removing the wood fragments that are mixed in with the concrete debris from a dedicated platform above the discharge conveyor. The materials are then delivered to the screening facility after the crushing operation is complete.

Fig 1.9 Shed for Picking

Plants for screening and washing

Screening is essential for separating recyclable aggregate into different sizes. The screening plant is made up of a series of substantial sieves that efficiently separate the materials into the desired sizes. The screened recycled aggregate is then brought to the washing plant for additional processing.

Fig 1.10. Screening Plant

Fig 1.11. Washing Plant

1.9 APPLICATIONS

In the past, repurposed aggregate has been applied as a landfill. Recycled aggregate is used in many different building fields now a days. Applications vary from one country to another.

1) Mix for concrete gutters and kerbs

Recycled aggregate has been used in concrete kerb and gutter mix in Australia. According to Stone's study in Building Innovation & Construction Technology (1999),

Fig 1.12: Recycled Aggregate as Road Kerb

the concrete kerb and gutter mix for the Lenthall Street project in Sydney included a combination of blended recycled sand and 10mm recycled aggregate.

2) Materials for a granular base course

In the construction of roads, recycled aggregate is used as granular base course. When utilised as a granular base course in the construction of roadways, recycled aggregate has proven to be superior to natural aggregate. Recycled aggregate can assist stabilise the base and improve the working surface for the pavement structure when building roads over wet subgrade areas.

Fig 1.13: Recycled Aggregate used as Granular Base Course

3) Materials for Embankment Fill

Fill for embankments can be made from recycled aggregate. Recycled aggregate can stabilise the base and provide a better working surface for the remaining operations when the embankment site is on wet subgrade areas.

4) Blocks for Paving

Hong Kong has used recycled aggregate as pavement blocks. The Hong Kong Housing Department claims that recovered aggregate is utilised in place of standard paving blocks. In 2002, a pilot project was launched to examine the durability of paving stones constructed from recycled aggregate.

Fig 1.14: Paving Blocks

5) Materials for backfill

According to the Norwegian Building Research Institute, reused aggregate can be used as retaining material. The pipe zone next to trenches can be used with reused concrete aggregate, according to laboratory study.

Fig 1.15 Backfill Materials Using Recycled Aggregate

6) Blocks for building

Aggregate recycled for construction purposes. The brick sound insulation blocks were made using recycled aggregate. During the laboratory testing, the masonry sound insulation blocks that were created had surpassed all standards.

Fig 1.16 Recycle Aggregate Used as Building Blocks

1.10 MERITS OF DEMOLITION WASTE

1. Recycled aggregates' special qualities enable greater compaction and constructability.
2. Higher yield: Since recycled aggregates weigh less per cubic metre than new aggregates do, overall project costs, hauling costs, and material costs are all decreased.
3. Compared to equivalent virgin quarry goods, recycled concrete aggregates weigh ten to fifteen percent (10%–15%) less.
4. Eco friendly
5. Sustainability - Using recycled aggregate will help reduce the quantity of garbage that is dumped in landfills. This will result in less quarrying.
6. Versatility

1 .11 OBJECTIVES OF THE PRESENT STUDY

1. To comprehend the features of demolition waste aggregate and the newly formed and hardened characteristics of demolition waste concrete using destructive and non-destructive methods.
2. To determine the effect of demolition material on concrete strength.
3. To determine the ideal replacement rate using demolition material.

CHAPTER 2

LITERATURE REVIEW

2 .1 GENERAL

Several studies have looked into using concrete demolition waste in place of coarse aggregate in concrete. The goal is to create durable concrete structures and increase their strength by swapping out inferior elements. Utilising discarded materials rather than fresh ones helps to improve the environmental friendliness of building. The use of waste aggregate from demolished buildings in concrete, which is a result of indirect building destruction, has been the subject of several research. The literature explicitly discussing the usage of demolition waste aggregate as a substitute for coarse aggregate in concrete is the subject of the current analysis. Information on the specifics of the literature review is provided in the next section.

2.2 REVIEW OF EXISTING LITERATURE

M.C. Limbachiya et al. (2006) In this work, the results of an experimental programme in the laboratory that examined the chemical and mineralogical properties of coarse recycled concrete aggregate (RCA) and their possible effects on concrete performance are discussed. Testing was done on both naturally occurring aggregates in the 16–4 mm size range as well as commercially generated coarse RCA. The source of the RCA had a negligible impact on the principal components, according to X-ray fluorescence (XRF) study, and the chemical composition of the recycled aggregates was similar to that of the natural aggregates. Although their numbers were proportional to their original composition, calcite, portlandite, and modest peaks of muscovite/illite were found in the recycled aggregates according to X-ray diffraction (XRD) research. The study evaluated the viability of coarse RCA for concrete applications by examining the effects of adding 30%, 50%, and 100% of it into concrete with an identical design strength. In the study, coarse RCA was used to directly substitute natural gravel in the manufacturing of concrete. According to test results, concrete's primary three oxides (SiO_2, Al_2O_3, and CaO) were unaffected by coarse RCA amounts up to 30%. Beyond this proportion, however, the composition of the original elements was matched by a modest drop in SiO_2 content and an increase in Al_2O_3 and CaO contents with increasing RCA content in the mix.

C. Medina et al. (2011) This study looked into the possibility of using recycled coarse aggregate made from waste products to make structural concrete. The goal was to partially replace natural coarse aggregates with recycled resources (15%, 20%, and 25%). The results show that environmentally friendly concretes built with recycled aggregates have stronger mechanical qualities than regular concrete. Furthermore, it was shown that the hydration process is not adversely affected by the recycled ceramic aggregate. Additionally, it was shown that the recycled ceramic aggregate and paste's microstructure at the interfacial transition zone (ITZ) was more compact than that of the natural aggregate and paste.

J. S. Ryou et al. (2013) In this study, a water-soluble polycarboxylate (PC) dispersant was used to improve the recycled concrete aggregate's (RCA) surface. The goal was to enhance RCA's qualities. Numerous factors were looked at, including the capacity to control slump loss, which was judged by tracking workability over time. The strength of RCA was also measured in order to assess its potential for use as a structural material. A carbonation test was also used to measure the amount of carbonation that occurred as a result of the cement mortar adhesion. The results showed that RCA coated with PC dispersion had better characteristics than RCA that had not been treated or crushed coarse aggregate. Both the physical characteristics of the newly-poured concrete and the hardened concrete's mechanical toughness showed these improvements.

Kumar et al. (2013) This study is part of a larger program that aimed to investigate the influence of replacing a portion of the coarse aggregate with demolition debris on the workability and compressive strength of recycled concrete. The study examined the compressive strength of recycled concrete at 7 and 28 days and compared it to traditional concrete. The test results indicated that up to 30% replacement of coarse aggregate with demolished debris resulted in comparable compressive strength to conventional concrete after 28 days.

Anagha Kalpavalli et al. (2015) In this study, the viability of using demolition waste as coarse aggregates in fresh concrete is examined. In order to create high-strength concrete, it entails assessing the qualities of the materials that make up concrete, particularly the demolished concrete wastes utilised as coarse aggregates. In order to determine whether recycled aggregate concrete is suitable for structural usage, the experimental investigation compares the characteristics and strength of recycled aggregate concrete to natural aggregate concrete at various replacement ratios. In this study, recycled aggregate concrete's outcomes and attributes are contrasted with those of conventional aggregate concrete. The results show that although while the strength of recycled aggregate concrete is less than that of natural aggregate concrete, it nevertheless falls within the permitted range for structural concrete applications.

Nováková et al. (2016) This study shows how defective components can be separately repurposed into useful recycled concrete aggregates (RCA). New precast pieces directly utilise this RCA. Testing of RCA and its use in novel concrete mixtures revealed that substituting up to 20% of raw aggregate with RCA has no negative effects on the physico-mechanical properties of the concrete.

Ashwini Manjunath B T (2016) In this study's experiment is conducted on E-waste particles which is used as both fine and coarse aggregates to examine their potential application in concrete. 0%, 20%, and 30% (equivalent to 0%, 10%, 20%, and 30%) were the replacement percentages that were taken into account. The compressive strength, tensile strength, and flexural strength of M20 Concrete were examined in relation to the impact of adding aggregates made of E-waste plastic. Positive strength characteristics were found in the results. The viability of using plastic scraps from e-waste instead of coarse aggregate was examined in the research. The study was specifically concerned with the compressive strength of concrete with an ideal cement content and 10% E-plastic component in the mix, which showed good stability and strength performance using 53-grade cement.

Ramesh Chandra Gupta et al. (2017) This study explores the use of waste polished granite from discarded tiles as a partial replacement for coarse pebbles in cement concrete. According to the results, adding waste polished granite to concrete causes a decrease in the material's strength in the compressive, flexural, and pull-off directions. Water permeability, abrasion resistance, and results in terms of absorption of water are all improved. It is recommended that all applications can benefit from concrete that contains waste polished granite and up to 20% replacement of natural coarse aggregate. For non-structural applications like paving, substitution amounts between 20 and 40 percent can be advised.

Reema et al. (2020) In this paper recycled concrete aggregate (RCA) has more water absorption, impact value, and bulk density than natural coarse aggregate. Concrete made with RCA is affected by its specific gravity and absorbability in terms of strength. Different ratios of recycled coarse aggregate were utilised as replacements, equal to 0%, 10%, 15%, and 20%, respectively: Concrete cubes were tested for compressive strength after 7 and 28 days of curing. The findings demonstrated that, in comparison to conventional concrete, the compressive strength and split tensile strength of the destroyed concrete dropped as the proportion of RCA in the concrete increased.

Simon Thomas et al. (2020) This study looks into the use of recycled aggregates made from construction and demolition waste (CDW) in concrete mixtures to encourage upcycling. A thorough analysis of current research and pertinent UK laws pertaining to the manufacture of concrete blocks is included in the paper. Using a sample of CDW recycled aggregates from a factory in Swansea as a case study, the initial tests were carried out. Two samples' compositions were determined by visual inspection and sieving tests, and the results were then contrasted with the original aggregates. According to the examination, more than 70% of the sample was made up of excavated soil waste, and the remaining portion was made up primarily of mortar, concrete, and ceramic waste with traces of organic material, glass, and plaster. Two concrete mixtures with different water-to-cement ratios were created, each including 80% recycled aggregates. Slump, absorption, density, and compressive strength were all tested for. The results showed a considerable loss in quality for both blends when compared to a reference sample. However, the debate identifies a number of issues, including heterogeneity and composition, that must be resolved in order to successfully use these recycled aggregates in the manufacture of concrete blocks. By using mixed CDW as recycled aggregates in concrete mixtures, the study's findings can improve the upcycling process.

A R Krishnaraja et al. (2021) In this study, we investigated the possibility of replacing a portion of the fine aggregate with crusher dust at the following percentages: 6%, 12%, 18%, and 24%. Additionally, we kept the sand content constant while partially replacing the gravel in the M20 concrete with waste tiles at percentages of 5%, 10%, 15%, and 20%. Compression, tensile, and flexural strength tests were performed on a total of 96 specimens. Based on the findings, we draw the conclusion that discarded tiles and crusher dust can be used in place of sand and gravel in concrete. According to our research, the ideal replacement rates for sand and gravel are 24% for crusher dust and 15% for waste tiles.

Devendra Kumar Sharma et al. (2021) The aim of this work is to systematically discover the fundamental characteristics needed to build concrete mixtures with coarse tyre rubber chips as aggregate. For the experimental examination, M20 grade concrete was chosen as the reference material, and rubber chips from scrap tyres were used in place of the usual coarse aggregate.

Viajy Kumar Jangid et al. (2021) The purpose of this study was to evaluate the effects of replacing cement, fine aggregate, and coarse aggregate in the manufacturing of concrete with sawdust from wood, foundry sand, and glass fragments, respectively. In the beginning, M25 grade (common concrete) design mix concrete was prepared in accordance with IS: 10262-2009 criteria. Subsequently, various sieved fractions of crushed industrial waste were used to substitute various components of the concrete both alone and collectively. The compressive strength was then assessed after 7 and 28 days. The goal of this study was to evaluate a concrete mixture that substituted foundry sand for the fine aggregate and sawdust for the cement in some of the coarse aggregate replacements (0%, 15%, 30%, and 45%) cement with sawdust (0%, 15%, 30%, and 45%).

CHAPTER 3

METHODOLOGY AND MATERIAL

3.1 PROBLEM STATEMENT

The demolished waste has been an issue since ages to be disposed off. With the concept of recycling in practice, there are numerous ways identified to utilize waste in construction practices. In the present study demolition material was used in place of the coarse aggregates in the following ratios: 0%, 10%, 20%, 30%, 40%, 50%, and 100%. For each substitution, six cubes were cast to determine strength 3 cubes after seven days strength and 3 cubes after 28 days strength another six cylinders were cast to determine the tensile strength 3 cylinder after 7 days and 3 cylinder after 28 days. As a consequence, 42 cubes and 42 cylinders in all were created. The results are determined using compressive strength test, split tensile strength test, and XRD analyses of the mixtures and rebound hammer test.

3.2 METHODOLOGY

The chapter discusses the qualities of the various materials used in this study, the various tests performed on the fresh and hardened concrete, steps to conduct the works and the experimental set up. The flowchart illustrating the steps adopted for the investigation is presented in figure 3.1.

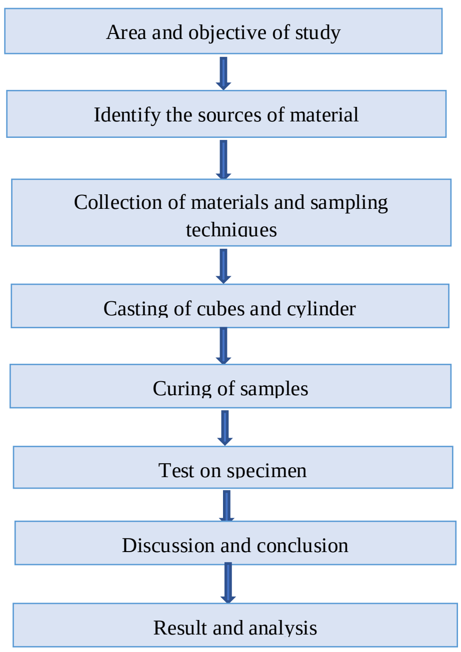

Fig 3.1 Flow chart of methodology

MATERIAL

3.3 CEMENT

The most widely utilised cement in the nation right now is of this grade. In RCC building where the concrete grade is up to M25, OPC 43 is utilised. Additionally, it is employed in the construction of precast items like blocks, tiles, and asbestos-containing products like sheets and pipes, as well as in non-structural projects like flooring and plastering.

Regular Ultra Tech Company Portland Cement of Grade 43, a locally available product, was employed for the experiment. Care was taken to guarantee that the procurement was made from single batching in airtight containers to avoid being influenced by atmospheric conditions.

Fig 3.2 Ultratech Cement

The cement obtained in this way was evaluated the physical requirements in accordance with IS: 12269 respectively. The physical properties of cement are listed below in Table 3.1

Table 3.1 Physical Properties of Cement

S.No	Properties	Test Result	Remarks
1	IST	130 min	Should not be less than 30 min as per IS:12269
2	FST	450 min	Should not be more than 10 hours as per IS:12269
3	Standard consistency	32%	As per IS:4031-Part4-1988
4	Specific gravity	3.15	Specific gravity of cement As per is code IS: 4031 part 11

3.4 FINE AGGREGATE

M Sand is a granular material used in construction that is mostly made up of mineral and stony fragments that have been finely split. It is therefore utilised as fine aggregate in concrete.

Fig 3.3 Fine Aggregate

The aggregate that is examined for its physical requirements, such as gradation, fineness modulus, moisture content, specific gravity, and water absorption.

Table:3.2 Test on Fine Aggregate

S.No	Properties	Test Result	Governing Code
1	M sand zone	Zone- II	IS 383
2	Fineness modulus	2.6	IS 383 [19]
3	Moisture content	0.51%	IS 2386 Part 3 [27]
4	Water absorption	1.9%	IS 2386 Part 3 [27]
5	Specific gravity	2.65	IS 2386 Part 3 [27]
6	Unit weight kg/m^3	1610	IS 2386 Part 3 [27

3.5 COARSE AGGREGATE

The term "coarse aggregate" often refers to the materials that are large enough to pass through a 4.75mm sieve. Local resources are employed to create the coarse aggregate. For this experimental with crushed angular material with diameters of 10 mm and 20 mm are used.

Fig 3.4 Coarse Aggregate

The aggregate which are tested for its physical requirement such as fineness modulus, moisture content, specific gravity, water absorption, Impact test, unit weight and Abrasion Value.

Table 3.3 Test on Coarse Aggregate

S.No	Properties	Test Result	Governing Code
1	Fineness modulus	6.4	IS 383 [19]
2	Moisture content	0.95%	IS 2386 Part 3 [27]
3	Specific gravity	2.74	IS 2386 Part 3 [27]
4	Water absorption	0.7%	IS 2386 Part 3 [27]
5	Impact test	18.25%	IS 2386 Part 4 [27]
6	Unit weight	1475 kg/m^3	IS 2386 Part 3 [27]
7	Abrasion value	26.82%	IS 2386 Part 4 [28]

3.6 WATER

Water has a big impact on the durability of concrete. It needs around 3/10th of its weight in water in order to be completely hydrated. A minimum water-cement ratio of 0.35 is required for normal concrete, according to practical experience. Chemical reactions between cement and water result in the formation of a cement paste, which binds to both large and small particles. The segregation and bleeding caused by excessive water use might make concrete weaker. The majority of the water is nonetheless absorbed by the fibres, which can aid in reducing bleeding. Blood can bleed from excessive water content, while insufficient water use results in poor workability.

Potable water is used as a resource throughout the mixing and hydration stages of the manufacturing of concrete. To obtain the intended result in this situation, a water-to-cement ratio of roughly 0.44 was used.

3.7 DEMOLITION WASTE

Aggregate waste is a product of the dismantling of concrete structures. The recycled aggregate for this study is sourced from an Indo Enviro Integrated Solution Limited facility in Shastri Park called the MCD Construction and Demolition Waste Recycling Process Plant. After strictly passing through 20mm and keeping 10mm IS sieve, this material is used. When compared to natural coarse aggregate, the waste from demolished concrete has a higher water absorption rate. The percentages of 0%, 10%, 20%, 30%, 40%, 50% and 100% separately were used to partially replace the coarse aggregate left over from demolished concrete. The aggregates' physical characteristics, including gradation, fineness modulus, specific gravity, moisture content impact test, unit weight, water absorption and Abrasion Value, were evaluated.

Fig 3.5 Demolition Waste of 10mm

Fig 3.6 Demolition Waste of 20mm

Fig 3.7 Transportation of Demolition Waste

Fig 3.8 Made building blocks using Demolition waste

Table 3.4. Physical Properties of Recycle Coarse Aggregate.

S.No	Physical Property	Test Result
1	Fineness modulus	6.4
2	Moisture content	3.85%
3	Water absorption	5.85%
4	Specific gravity	2.46
5	Impact test	31.20%
6	Unit weight	1426kg/m^3
7	Abrasion value	36.51%

3.8 TEST TO BE CONDUCTED ON FRESH CONCRETE

3.8.1 WORKABILITY: Workability is a term used to indicate how easily a material may be mixed, carried, placed, and finished without any segregation or undue resistance. This term is generally used in reference to concrete or other construction materials. It evaluates how easily a material can be handled and moulded throughout the construction process. Several elements, including water quantity, aggregate size and shape, cement content, admixtures, and the presence of any extra additives, affect workability. A material with good workability is frequently required because it makes construction operations more effective and efficient.

Fig 3.9 Slump Test

3.9 TEST TO BE CONDUCTED ON HARDENED CONCRETE

1. XRD test
2. Compressive strength test
3. Split tensile strength test
4. Rebound hammer test

3.9.1 X-RAY DIFFRACTION ANALYSIS TEST

Crystalline minerals are identified qualitatively and their components are determined through XRD analysis. It is frequently employed to evaluate the strength and composition of crystalline materials. The phases present are recognised via X-ray diffraction. The numerous phases of recycled coarse aggregates made from building waste, including quartz, calcite, and portlandite, were examined in this work using XRD. The RCA samples were ground into a fine powder and dried in the lab for 24 hours before to the XRD analysis. Then, a layer of the finely ground powder, which was 1mm thick, was deposited in a sample container and placed in the computer-controlled diffractometer device's measurement circle. The measurement was started using a continuous scanning mode with a scanning range of 10°-90° on a 2 drive axis at a scan speed of 3.0deg/min and a sampling pitch of 0.020 deg. Using specialised XRD software, a qualitative examination of the resultant scan data was performed. An analysis of comparisons was used to determine the sample components and produce a graph showing the association between 2theta and intensity.

3.9.2 COMPRESSIVE STRENGTH TEST PROCEDURE

Create the specimen by mixing the concrete according to the specifications, compacting it properly, and pouring it into the desired mould shape of a (15 x 15 x 15) cm^3 cube. After 24 hours, demoulding the specimen and place the specimen in water for curing.

The methods below describe how to evaluate a cube's compressive strength using a vibrating machine.

- First, a cube specimen is made by pouring the concrete mixture into the cube mould. A vibrating machine is used to compact the mixture in layers, guaranteeing optimum compaction. To eliminate any air voids and attain maximum density, each layer is vibrated for a certain amount of time.

- A trowel is used to level and smooth the cube's surface when compression is finished. The cube is then placed in a curing tank or moist room for a certain curing duration, usually 28 days, and covered with a damp cloth or plastic sheet to prevent moisture loss.
- After the curing process is complete, the surplus material is cut to create smooth and parallel surfaces before the cube is removed from the mould. With the use of a calliper or ruler, the cube's dimensions are precisely measured.
- The cube is then properly aligned by placing it on the lowest platen of a compression testing machine. The device uses a constant rate to progressively apply the weight on the cube. The greatest load the cube can withstand before breaking is recorded by the machine as the load at failure.
- The compressive strength of the cube is estimated using the recorded load by dividing the greatest load by the cross-sectional area of the cube. For accurate findings, it is standard procedure to test many cube specimens and determine the average compressive strength.

$$\textbf{Compressive Strength} = \frac{\textbf{load}}{\textbf{area}}\ \textbf{N/mm}^2$$

Fig 3.10 Compressive Testing Machine (CTM)

3.9.3 SPLIT TENSILE STRENGTH TEST PROCEDURE

A vibrator is used to conduct the split tensile strength test. The process consists of the following steps:

Make cylinder-shaped concrete specimens of a specific size first. The specimen should then be supported horizontally and subjected to a vertical load along its axis. The vibrator should then be attached to the specimen's upper surface and turned on to produce vibrations. Better compaction and consolidation of the concrete are made possible by these vibrations. Remove the vibrator and let the specimen set after a predetermined amount of vibration has occurred. Last but not least, divide the specimen along its axis by applying a diametrical compressive load to it using a testing machine. The concrete specimen's split tensile strength is calculated as the maximum load at failure.

$$\textbf{Split Tensile Strength} = \frac{2p}{\pi dl} \ \text{N/mm}^2$$

Fig 3.11 Universal Testing Machine (UTM)

3.9.4 REBOUND HAMMER TEST

The rebound hammer is a tool for non destructive testing that gauges how quickly a spring-driven mass bounces back after hitting a concrete surface. Rebound numbers, which are results from the rebound hammer and are connected to the hardness of the concrete's surface, are acquired.

3.10 MIX DESIGN FOR M25 GRADE CONCRETE AS PER IS 10262

Characteristic compressive strength required in the field at 28 days: 25 MPa

OPC 43's specific gravity is 3.15.

The coarse aggregate's specific gravity is 2.74.

Fine aggregate specific gravity: 2.65

f1ck = fck + ks

= 25 + (1.65 x 4)

= 31.6 MPa is the target mean strength.

1 percent air in 20-mm aggregate

Ratio of free water to cement (w/c):

For the PCC (moderate exposure condition),

A minimum amount of cement is 240 kg,

and the w/c ratio is 0.44.

the water content solution

Water content for 20mm aggregate is 186 kg.

Water content for a 100mm slump is

(186 + 186 x 6)/100 = 191.58 litres.

Using the formula: 192 litres of water

Regarding the superplasticizer:

0.5 - 1 = 15 – x

1 - 1.5 = x – 30

x - 30 = 15 – x

2x = 45

x = 22.5% reduction for a 1% decrease in water content.

Superplasticizer taken = 1% of the weight of all the cement.

Water content is therefore equal to (192 x 100 - 22.5)/100,

or 148.8 litres. (rounded to 149 kg)

determining the cement content:

w/c ratio equals 0.44

Cement content is 149 kg / 0.44 kg,

or 339 kg.

Both coarse and fine aggregate content are used:

(w/c) ratio of 0.44 for coarse aggregate in Zone II

For zone II, the ratio of coarse to fine aggregate is as follows:

20 mm equals 0.62 m^3

Fine aggregate = 0.36 m^3

Corrected proportion = 0.62 + (0.01 x 2) = 0.64 m^3

Calculating a mix:

Volume total is 1 m^3.

Entrapped air volume = 0.01 m^3

Cement volume is equal to 339 x 1 / (3.15 x 1000) = 0.1076 m^3.

Water volume = 149 / 1000 = 0.149 m^3.

Water mass volume equals 149 kg.

3.39 kg of admixture is equal to 1% of the cement content.

MIX PROPORTION

339 kg of cement

192 litres of water

667.8 kg fine aggregate

1227.52 kg for coarse aggregate

Water to cement ratio equals 0.44

Cement, fine aggregate, and coarse aggregate in the following ratios: 1: 1.96: 3.62

A cube's worth of calculations:

Cube volume equals 3.375 x 10^{-3} m^3 or 150 x 150 x 150 mm^3.

Required cement is equal to 1.144 kg or 339 x 3.375 x 10^{-3} kg.

Required coarse aggregate is equal to 4.1428 kg or (1227.52 x 3.375 x 10^{-3}).

For 20 mm aggregate, multiply 613.76 by 3.375 by 10^{-3} to get 2.0714 kg.

613.76 x 3.375 x 10^{-3} = 2.0714 kg for 10 mm aggregate

Fine aggregate weighs 2.253 kg or 667.8 x 3.375 x 10^{-3}.

For 6 cubes

Required cement weighs 6.864 kg.

Add 20% more for losses, which equals 8.236 kg.

20mm coarse aggregate weighs 12.4284 kg.

Adding 20% more equals 14.914 kilogrammes.

10mm coarse aggregate weighs 12.4284 kg.

Adding 20% more equals 14.914 kilogrammes.

13.518 kg fine aggregate

Adding 20% more equals 16.22 kilogrammes.

3.01725 kg = water

Adding 20% more equals 3.62 kg.

Blend = 0.0686 kg

Adding 20% more equals 0.0823 kilogramme.

3.11 EXPERIMENTAL DETAIL

The primary objective of the study is to develop a concrete that is more stable and durable compared to regular concrete by replacing coarse particle. A total of 84 specimens, consisting of 42 cubes and 42 cylinders, were produced and subjected to strength testing and comparative analysis. Mix designs were completed for all the material substitutions the cubes and cylinders were casted for 7 and 28 days as shown in table 3.5 below.

Table 3.5 Casting of Cubes and Cylinder

S.No	% Replacement of RCA	Sample of Cubes are Casted 3 Cubes of 7 days Strength and 3 Cubes for 28 Strength days	Sample of Cubes are Casted 3 Cubes of 7 days Strength and 3 Cubes for 28 Strength days
1	0	6	6
2	10	6	6
3	20	6	6
4	30	6	6
5	40	6	6
6	50	6	6
7	100	6	6

3.12 CURING OF CONCRETE

For 7 and 28 days, the cast cube and cylinder were submerged in drinkable water. The water in the tank is kept between 27 and 30 degrees Celsius for curing.

Fig 3.12 Curing of Concrete

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 GENERAL

The results of numerous tests performed on concrete specimens, including compressive strength and tensile strength tests, are presented in this chapter. Additionally, X-ray diffraction (XRD) research was done as part of microscopic investigations. In the chapter's conclusion, the findings and conclusions of the research are presented using graphs, tables, and microscopic image.

4.2 SLUMP TEST

The results of measuring the slump of the concrete with recycled coarse materials are shown below in Table 4.1

Table 4.1 Workability Comparisons Between Different % Replacement of RCA

S.No	Types of concrete	% of Replacement of RCA	Slump Value in (mm)
1	Normal Concrete	0	100
2	RCA Concrete	10	95
3	RCA Concrete	20	93
4	RCA Concrete	30	88
5	RCA Concrete	40	85
6	RCA Concrete	50	80
7	RCA Concrete	100	70

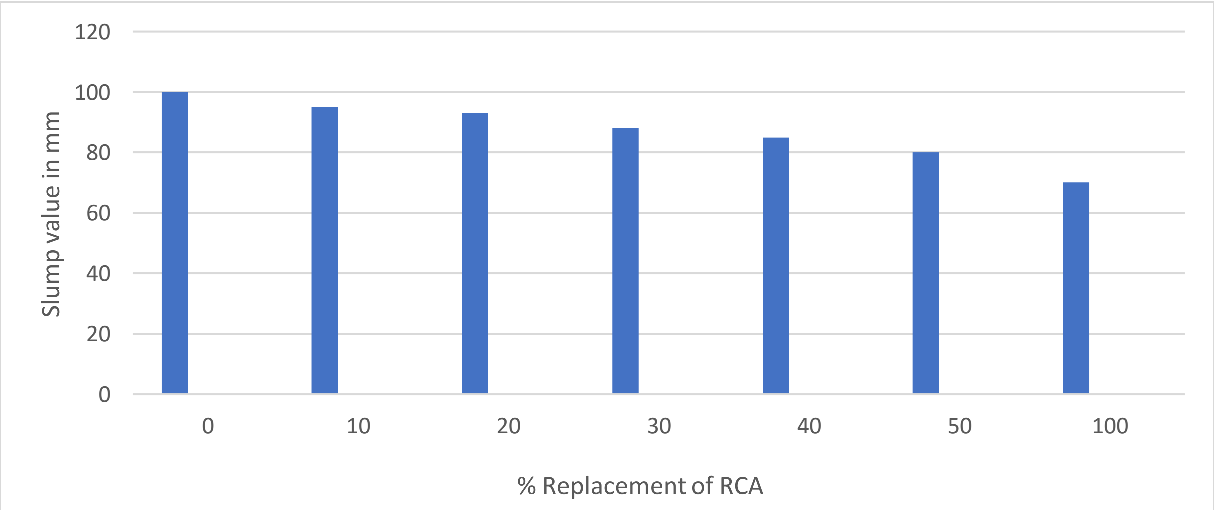

Fig 4.1 Slump Value of Different % Replacement of RCA

The slump value is decrease as the percentage of replacement of RCA increase.

4.3 STRENGTH CHARACTERISTICS OF OBTAINED HARDENED CONCRETE

The results from the mechanical strength tests specified below are discussed in details in subsequent stanzas.

1. Compressive strength test
2. Split tensile strength test
3. Rebound hammer test
4. XRD test

COMPRESSIVE STRENGTH TEST

Cube compression tests were performed to determine the effects of replacing the coarse aggregate with demolition waste. Replacement ratios of 0%, 10%, 20%, 30%, 40%, 50%, and 100% were taken into account. Both the 7 and the 28 days were used for the examinations.

Fig 4.2 Different Types of Cracks

Fig 4.3 Different Types of Rupture

Table 4.2 Average Compressive Strength Value of Cube

S.No	Types of Concrete	% Replacement of RCA	7 days strength (MPa)	28 days strength (MPa)
1	Normal concrete	0	22.62	34.36
2	RCA Concrete	10	24.63	34.52
3	RCA Concrete	20	24.65	34.74
4	RCA Concrete	30	24.18	34.41
5	RCA Concrete	40	21.03	27.36
6	RCA Concrete	50	20.84	27.04
7	RCA Concrete	100	11.19	24.43

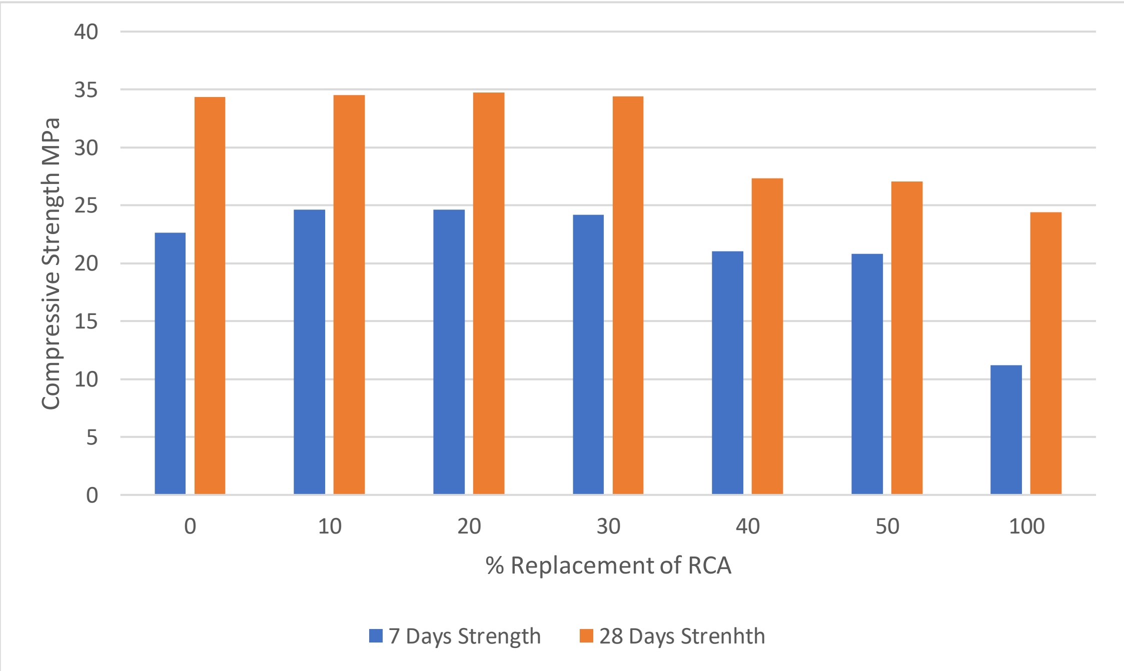

Fig 4.4 Average Strength Variation for Various % Replacement of RCA in Cube

SPLIT TENSILE STRENGTH TEST

On cylinders, the split tensile strength was assessed by partially replacing coarse aggregate with demolition waste at different ratios: 0%, 10%, 20%, 30%, 40%, 50%, and 100% on the 7th and 28th days.

Fig 4.5 Casting of Cylinder

Fig 4.6 After Curing of Sample

Fig 4.7 Load Applied on the Cylinder

Fig 4.8 Crack Formation on the Cylinder

Fig 4.9 Formation of Various Crack on the Cylinder

Fig 4.10 Large Crack Developed on the Cylinder

Fig 4.11 Crack Seen on Length Wise

Fig 4.12 Testing of Sample After 28 Days

Table 4.3 Average Split Tensile Strength Value of Cylinder

S.no	Types of Concrete	% Replacement of RCA	7 days strength (MPa)	28 days strength (MPa)
1	Normal concrete	0	1.97	2.72
2	RCA Concrete	10	2.14	3.18
3	RCA Concrete	20	2.10	2.96
4	RCA Concrete	30	2.02	2.87
5	RCA Concrete	40	1.87	2.70
6	RCA Concrete	50	1.78	2.58
7	RCA Concrete	100	1.51	1.91

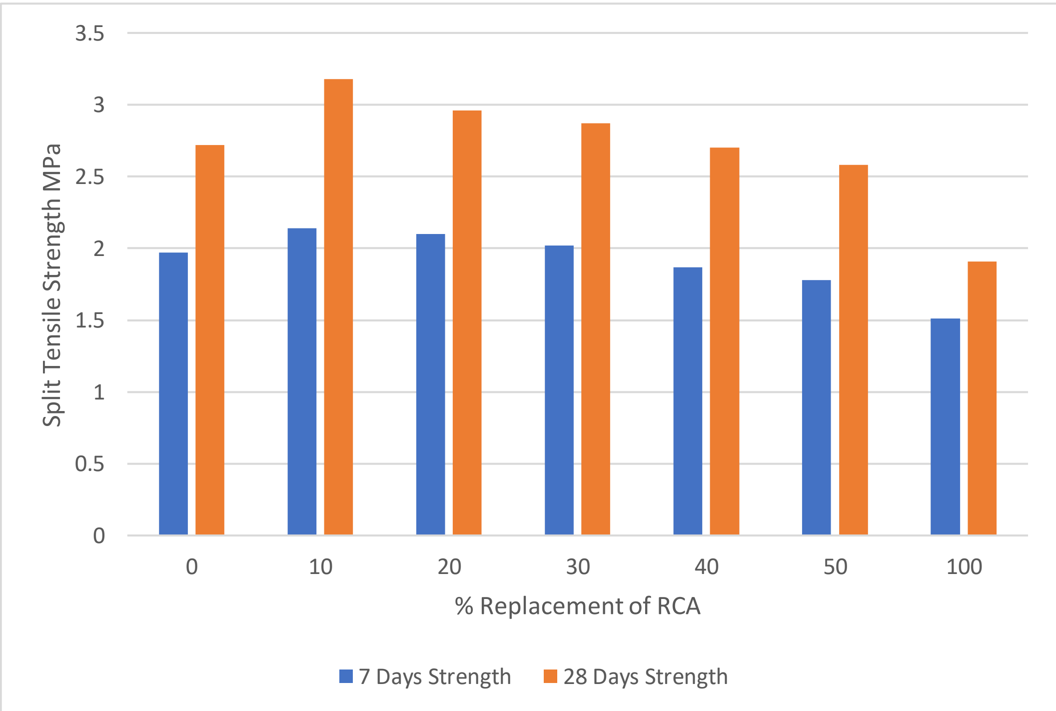

Fig 4.13. Strength Variation of Different % Replacement of RCA in Split Tensile Test

REBOUND HAMMER TEST

When conducting the rebound hammer test, the instrument is positioned perpendicular to the surface of the material under examination. The plunger is then applied to the surface with a predetermined force, often achieved by fully compressing the spring-loaded mechanism. It is important to note that the plunger should be pressed at five different locations, and the average of these five readings should be taken into account for accurate results. This approach helps ensure a comprehensive assessment of the material's compressive strength

Fig 4.14 Rebound hammer Reading 4

Fig 4.15. Rebound hammer Reading 5

Table 4.4 Rebound Hammer Average Strength

S.no	Types of Concrete	% Replacement of RCA	7 days strength (MPa)	28 days strength (MPa)
1	Normal Concrete	0	23.20	34.50
2	RCA Concrete	10	24.60	34.70
3	RCA Concrete	20	23.10	34.20
4	RCA Concrete	30	22.16	33.50
5	RCA Concrete	40	21.83	30.20
6	RCA Concrete	50	17.33	29.30
7	RCA Concrete	100	16.22	20.80

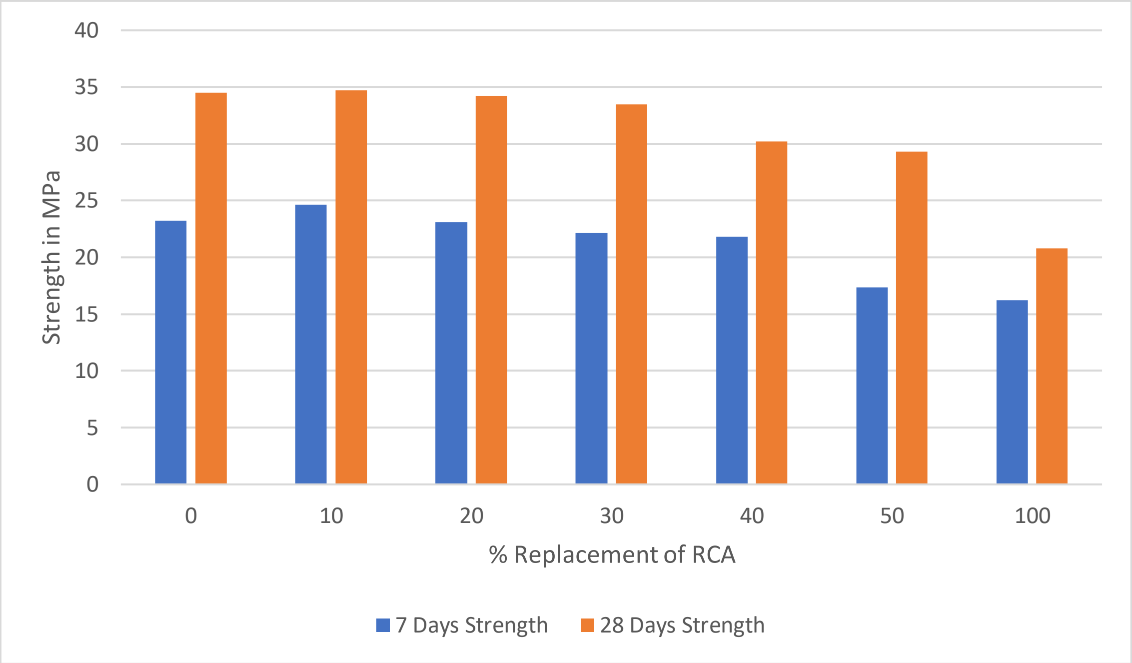

Fig 4.16 Strength Variation of Different % Replacement of RCA in Rebound Hammer Test

XRD TEST

X-ray powder diffraction (XRD) is a quick analytical technique that can provide information on the size of the unit cell as well as the phases that are present in a crystalline substance. The sample is finely powdered, completely mixed, and its general makeup is ascertained.

Fig 4.17: X-Ray Power Differaction

To confirm the mineral phases connected to the waste materials, X-ray diffraction (XRD) investigation was done. Alite, Belite, and pentlandite were found in cement, according to the XRD data, as shown in figure (4.18). According to figure (4.19), the mineral phases that were detected in the demolition waste were quartz, calcite, and portlandite. Figure (4.20) illustrates the phases that were found in the coarse material, which included quartz, portlandite, calcium, silicate hydrate, and calcium silicate. As seen in figure (4.21), the fine material also revealed phases such quartz (SiO2), calcite, mica, dolomite, feldspar, and chlorine.

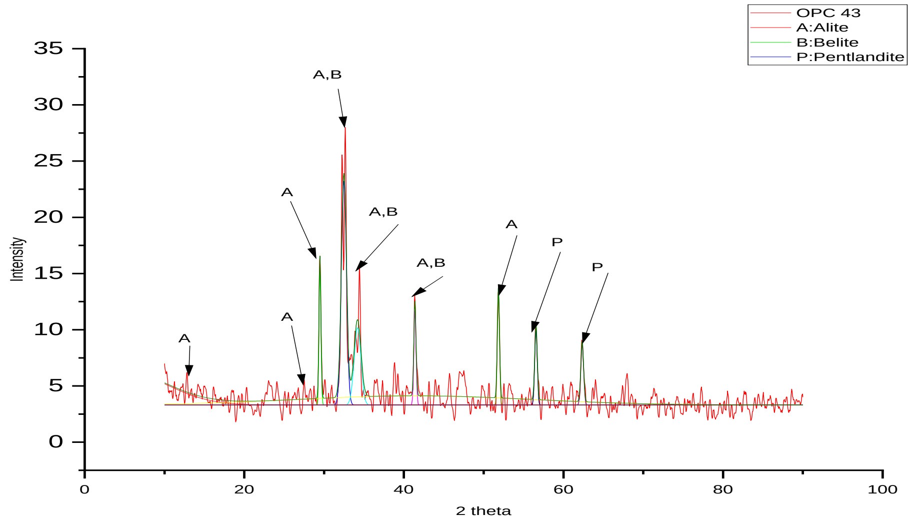

Fig 4.18 XRD of OPC cement

Table 4.5 Calculation of Peak Position and FWHM in OPC Cement

S.No	Peak Position	FWHM
1	5.01618	12.7681
2	29.48515	0.28767
3	32.48474	0.75313
4	34.19082	0.99937
5	41.38655	0.32988
6	41.38655	34.5558
7	51.84745	0.3123
8	56.55321	0.36017
9	62.35053	0.41311
10	68.37665	4.00E-05

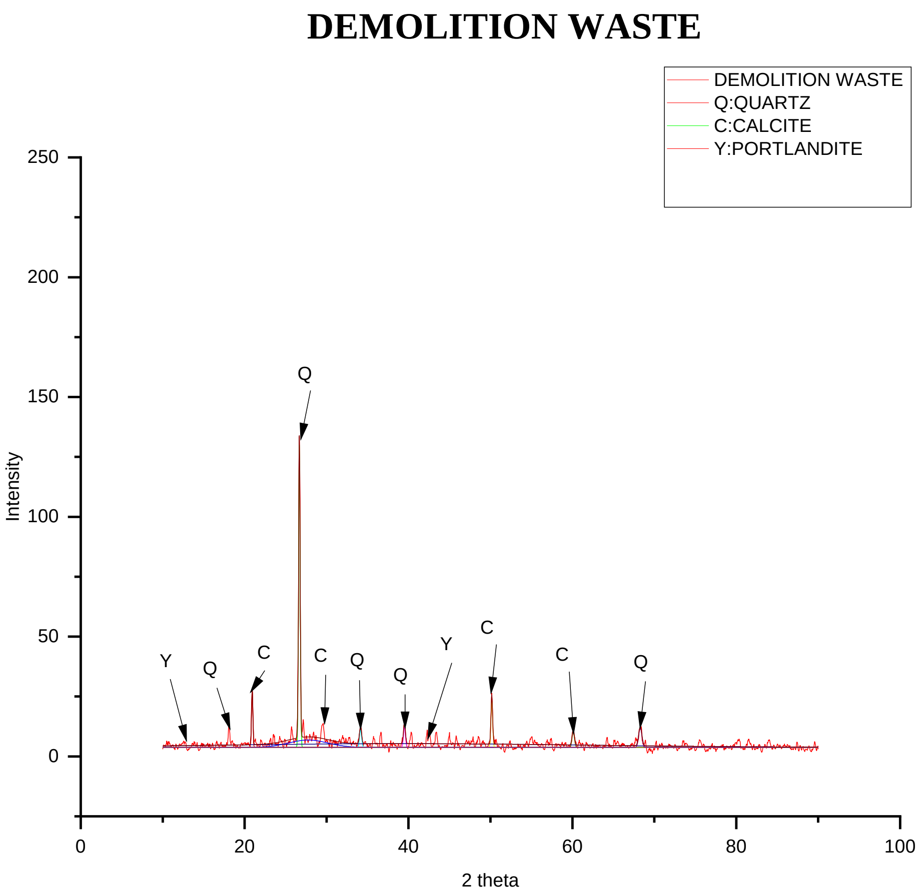

Fig 4.19 XRD Of Demolition Waste

Table 4.6 Calculation of Peak Position and FWHM in Demolition Waste

S.No	Peak Position	FWHM
1	20.91961	0.18925
2	26.68188	0.22705
3	27.75594	5.53198
4	34.14642	0.28956
5	39.50277	0.27572
6	50.16192	0.22997
7	60.1042	0.31476
8	39.50277	51.14683
9	68.28553	0.43953

NATURAL COARSE AGGREGATE

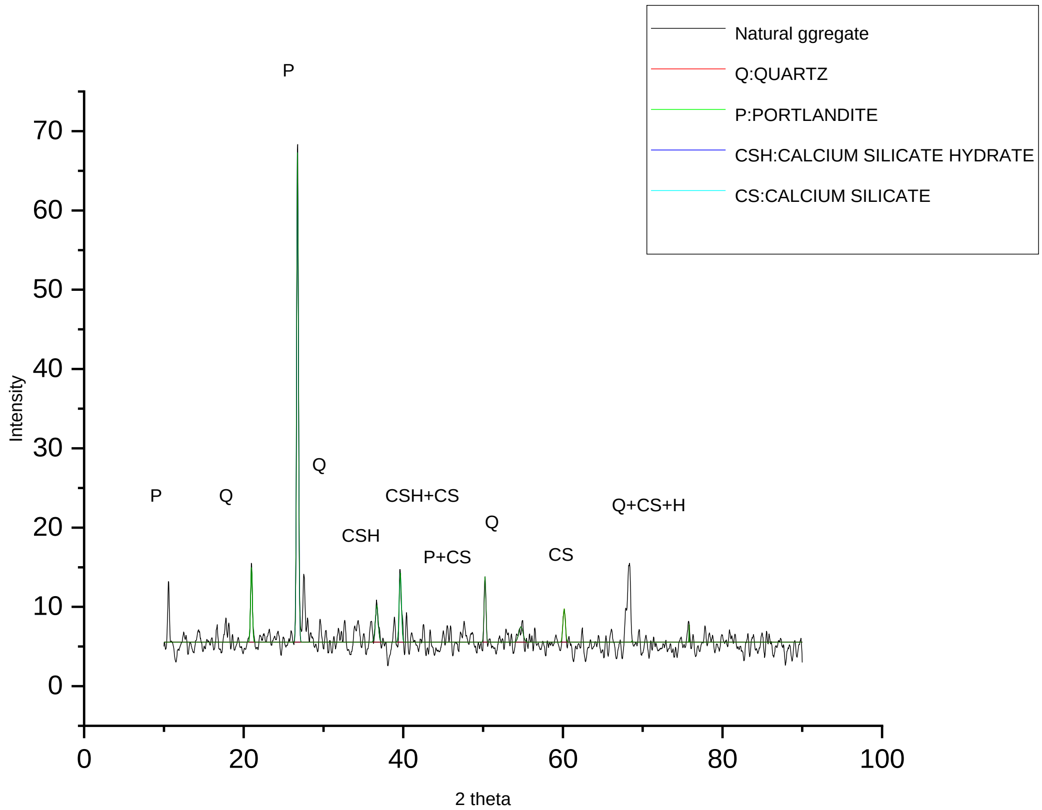

Fig 4.20 XRD of Natural Coarse Aggregate

TABLE 4.7 Calculation of Peak Position and FWHM in Natural Coarse Aggregate

S.NO	Peak Position	FWHM
1	10.78723	0.00739
2	20.97551	0.26437
3	26.74955	0.26903
4	39.6272	0.3214
5	50.23953	0.25552
6	60.15874	0.33189
7	68.61914	0.017
8	36.678	0.41686
9	54.73778	0.61688
10	75.82948	0.0094

FINE AGGREGATE

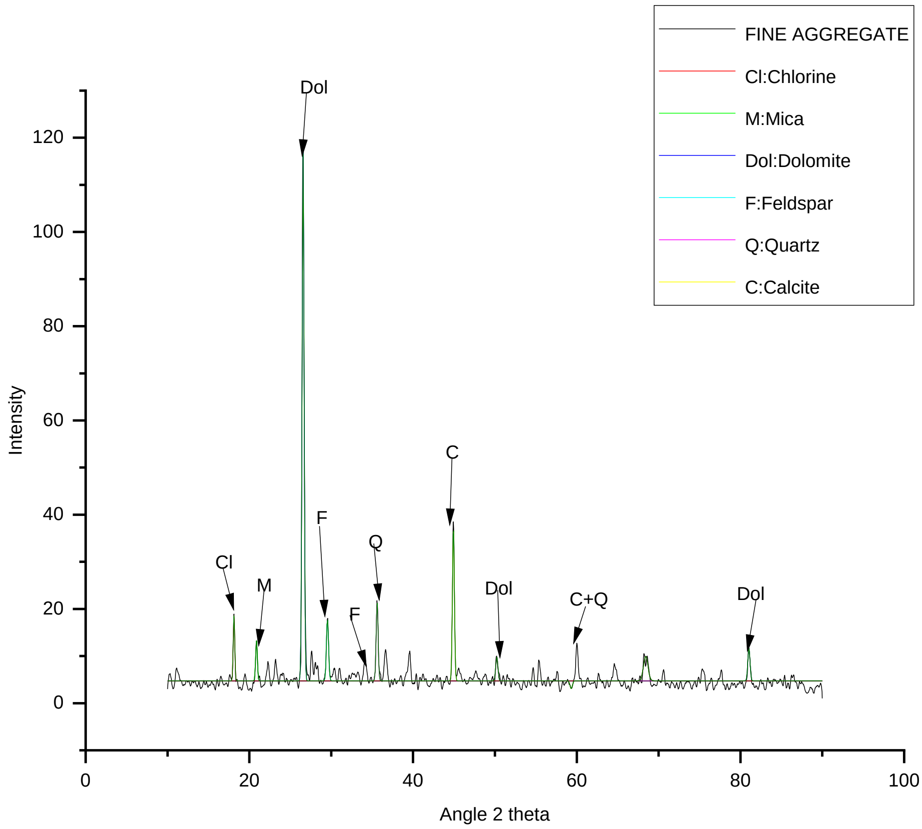

Fig 4.21 XRD Of Fine Aggregate

Table 4.8 Calculation of Peak and FWHM in Fine Aggregate

S.NO	Peak Position	FWHM
1	18.12065	0.21412
2	20.87006	0.24165
3	26.56451	0.29378
4	29.54695	0.30561
5	35.61084	0.28453
6	44.93115	0.28112
7	59.31642	0.33398
8	81.03735	0.30431
9	50.22669	0.31018
10	68.42731	0.64165

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 CONCLUSION

The following conclusion can be drawn from the study.

1. The slump value reduces as the proportion of demolition waste used for replacement increases. Other parameter such as water absorption, moisture content, Specific gravity, impact test, abrasion value and unit weight are also affected.
2. At 100% replacement of natural aggregate with RCA the compressive strength of concrete decreased by approximately 28.89% after 28 days.
3. The ideal replacement rate for natural aggregate with demolition waste is 30%.
4. Split tensile strength and compressive strength of concrete are sufficient up to 30% replacement, however after that point demolition aggregate reduces the strength's value.
5. The sample containing 30% recycled concrete aggregate (RCA) was found to be the most cost-effective, with a cost 9% lower than the control mix sample, according to the results of the sample cost analysis.
6. Therefore, it is logical to conclude that adding (C&D) waste to concrete not only lowers construction costs but also promotes waste recycling and effective utilisation.

5.2 FUTURE SCOPE

1. It has been determined that recycling and reusing building wastes is an appropriate solution to the issues of dumping thousands of tonnes of rubbish together with a dearth of natural aggregates. Concrete made using recycled aggregates is a beneficial building material from a technical, environmental, and financial standpoint. Durability study in such should also be made to see long performance of such concrete.

2. Using recycled coarse aggregate in construction has a number of proven applications. To change our design codes, specifications, and method for using recycled aggregate concrete, more research and the beginning of projects are required. Due to the sizeable infrastructure projects that will be launched in the upcoming years, the usage of RCA in building projects in India needs to be given more attention.

3. Using RA will help ensure that society develops sustainably by conserving on materials, energy, and natural resources. There are some obstacles to increasing the use of RA in India, such as the low cost of virgin aggregate, the dearth of recycling facilities in the right places, the unavailability of the right technology, the lack of knowledge, the absence of specifications and rules, the large initial investment, etc.

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