In charge
Pakistan Engineering Council, Funding Section

Dear sir,

Please find attached to this document a detailed report of our project, Sustainable Utilization of Demolished Cement Concrete in Reinforced Concrete Members. For this project, we have won funding of Fifty Thousand Rupees, out of which 40% (nineteen thousand) is released; therefore, you are requested to release the remaining 60%. (thirty one thousand) of the fund. Details of the group members are given below.;

Malak Sheraz Khan	AUP-19FL-BECE-15392
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Sami Ullah	AUP-19FL-BECE-15783
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Funding Details

Total Fund	RS 50,000
Released Fund	RS 19,000
Remaining Fund	RS 31,000

Supervisor: ENGR. BABAR ILYAS

TITLE: SUSTAINABLE UTILIZATION OF DEMOLISHED CEMENT CONCRETE IN REINFORCED CONCRETE MEMBER

SUSTAINABLE UTILIZATION OF DEMOLISHED CEMENT CONCRETE IN REINFORCED CEMENT CONCRETE

Introduction

- Concrete is most widely used as a construction material in the developing countries.
- The concrete which is generated from renovation, repair and demolition of houses, large building structures, roads, bridges, piers and dams is called demolished concrete.
- Utilization of demolished concrete is economical and is helpful to reduce the consumption of natural resources.

Problem Statement

- Dumping of solid waste is widely faced issue in developed as well as developing countries.
- The utilization of solid waste in construction materials is the need of the day.
- To minimize the environmental impacts from the waste product, we must find a way to reuse it.

Methodology

Sieve Analysis

Water Absorption

Shape Test

Soundness Test

Compression Test

Split Tensile Test

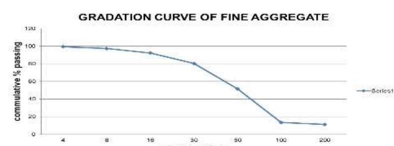
Conclusion

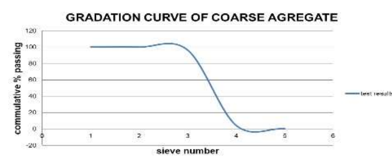
Specimens of 25% and 50% replacement under compression were satisfying and gave optimum results.

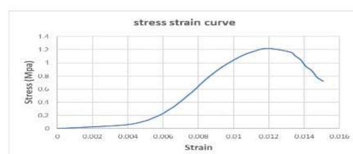
Demolished Concrete

Dumping site

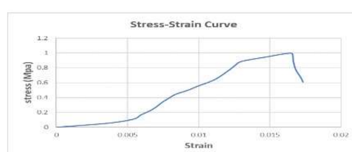
Results







25% Replacement



50% replacement

Supervisor :

Babar Ilyas

Group Members :

Jibran Khan (18748)

Sami Ullah (15783)

Abbas Khan (15965)

Malak Sheraz Khan (15392)

Detail of Upcoming Expenditure		
S. No	**ITEMS**	**PRICE (Rs)**
1	Material	7000
2	Sodium Sulphate (Na2So4)	4400
3	Universal Testing Machine Test	5600
4	Poster	4000
5	Thesis Printing	10000
6	Transportation (Materials to Testing Lab)	Depend on Location

SUSTAINABLE UTILIZATION OF DEMOLISHED CEMENT CONCRETE IN REINFORCED CONCRETE MEMBER

Final Year Project UG 2022-23

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Session: 2019-2023

SUSTAINABLE UTILIZATION OF DEMOLISHED CEMENT CONCRETE IN REINFORCED CONCRETE MEMBER

Thesis submitted in partial fulfillment of the requirements for the degree of B.E

Civil Engineering

BY

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Dedication

This study is devoted to our adored and treasured parents, who stood by us during every difficulty we encountered and selflessly put aside their own comfort for the sake of our bright prospects. It is also a tribute to our mentors who guided us to face life's trials with innovation and bravery, moulding us into the individuals we have become today.

Acknowledgements

First and foremost, we express our deepest gratitude and heartfelt thanks to the Almighty Allah for His blessings, guidance, and unwavering support throughout our thesis journey.

We would like to extend our sincere appreciation to Abasyn University Peshawar for providing us with an exceptional platform for learning and growth. Our deepest gratitude is reserved for Engr. Babar Ilyas, our thesis supervisor and a lecturer at Abasyn University Peshawar. We are immensely grateful for his invaluable guidance, mentorship, and unwavering support. Despite his busy schedule, he generously offered his expertise and provided us with constructive feedback throughout the thesis process. His dedication and commitment have been instrumental in shaping our research work

We would like to acknowledge the invaluable contributions of all the lab engineers and all the laboratory technicians. Their unwavering dedication, technical expertise, and cooperation have been indispensable throughout our research.

Lastly, we owe an immeasurable debt of gratitude to our parents, whose unwavering love, prayers, care, and sacrifices have been the bedrock of our education and preparation for a prosperous future. Their constant support and encouragement have fueled our ambition, and we are forever grateful for their unwavering belief in our abilities.

We are profoundly grateful to our parents, whose unwavering love, support, and sacrifices have been the cornerstone of our education and the driving force behind our research journey. Their constant encouragement, belief in our abilities, and selfless dedication have been a source of strength and inspiration

Abstract

Millions of tons of demolished concrete are generated worldwide each year, presenting a significant waste management challenge. Dumping this waste requires vast areas and has adverse environmental and economic consequences. To address this issue, this research is about to investigate the sustainable utilization of demolished concrete in reinforced concrete. By recycling demolished concrete as a substitute for coarse aggregate, the research seeks to reduce waste, conserve natural resources, and lower construction costs. Preliminary tests, including sieve analysis, water absorption, shape tests, impact value, and soundness tests, were performed on the aggregates and recycled demolished concrete used in the concrete mixtures. The compressive, flexural, and tensile strength of concrete samples containing various percentages (25%, 50%, and 100%) of demolished concrete as well as the workability of the concrete with a constant water-cement ratio were examined. The utilization of demolished concrete in reinforced concrete can effectively manage waste, reduce the depletion of natural resources, and result in cost savings. However, mechanical properties of concrete like compressive, flexural, and split tensile strengths decrease as the percentage of demolished concrete increases, while workability improves with the inclusion of demolished concrete. It is recommended to limit the replacement of coarse aggregate with demolished concrete to around 25% to maintain satisfactory mechanical properties and future studies should investigate the long-term durability and performance of concrete containing less than 25% demolished concrete.

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List of Abbreviations

D.C	Demolished Concrete
SW	Solid Waste
MSW	Municipal Solid Waste
RCA	Recycled Concrete Aggregate
OPC	Ordinary Portland Cement
RHA	Rice Husk Ash
ASTM	Autonomous mobility on demand
Psi	Pounds per square inch
KN	Kilonewtons
PPC	Portland Pozzolana Cement
UTM	Universal Testing Machine

Chapter 1
Introduction

1.1 General

Concrete is a composite material made of fine and coarse aggregate that is joined by a fluid cement (cement paste) that eventually solidifies (cure). The most popular building material worldwide is concrete, which is utilized in second place to water worldwide in terms of usage. When compared to steel, wood, plastics, and aluminium combined, its global utilization is two times more. By 2025, it is anticipated that the ready-mixed concrete market, which makes up the largest portion of the global concrete market, will generate revenues of more than $600 billion (Ahmadi, M. Farzin, Hassani A, & Motamedi. M, 2017). Numerous environmental effects are brought on by this extensive use. Particularly noteworthy are the significant greenhouse gas emissions from the cement production process, which account for 8% of all emissions globally (Tayeh, 2021). Other environmental issues include extensive illicit sand mining, environmental effects including increased surface runoff or the urban heat island effect, and potentially harmful components that could have an influence on public health. For achieving a circular economy, there is a lot of research and development being done to try to lower emissions or make concrete a source of carbon sequestration. In addition to being a solution to lessen the pollution from other sectors by absorbing wastes like coal fly ash or bauxite tailings and residue, concrete is anticipated to be a crucial component of constructions robust to climate disasters. Because it can be moulded into any shape, concrete is utilized variety of applications.

Demolished Concrete

The concrete produced during home restoration, building repairs, and building destruction, as well as during the construction of roads, bridges, piers, and dams. In the current economic crisis, employing demolished concrete has proved successful in cutting the cost of construction materials by using the demolished rubble and aggregate from the concrete or the concrete itself.

Destruction of buildings, bridges, dams, piers, and roads results in millions of tons of demolished concrete each year, which is having a significant negative impact on the environment. This much concrete cannot be dumped because doing so would take up a lot of room. It is occasionally utilized as backfill and in the grades of roadways. Manufacturing cement is responsible for eight to ten percent of all global CO2 emissions (Mistri A, Bhattacharyya S, K. Dhami, & N. Mukhe, 2020). When clays and limestone are crushed and heated to high temperatures, the greenhouse gas is emitted. The concept of industrial ecology, green chemistry, and nano-engineering, which examines the behaviour of the structure and organization of cement nanoparticles in the mix for achieving higher performance, have all been used by researchers to arrive at some alternatives that can significantly reduce high energy consumed and environmental impacts during the fabrication process of cement.

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Recyclyng Plant

The most widely used manmade materials worldwide are those based on cement. In our nation, green building is the hottest trend right now. Using green concrete when constructing has enormous potential environmental benefits for society. As the name implies, green concrete is environment-friendly and protects the environment by employing waste products produced by businesses in various forms, such as rice husk ash, micro silica, etc. to create resource-saving concrete structures. Green concrete is frequently very inexpensive to create since it directly substitutes waste products for some of the cement, reducing the amount of energy required to produce one unit of cement and reducing emissions and wastewater. Green concrete is used to reduce energy consumption, emissions, and wastewater.

Green concrete is more durable and stronger than regular concrete. It is reasonable to anticipate that technology can be created to lessen the CO2 emissions associated with the production of concrete. Due to its high energy needs, the building sector generally has a significant negative influence on the environment. More people and nations are concerned about their futures because of the knowledge raised over the previous several years about the greenhouse effect and damage to the environment.

1.2 Study Area

Every year, emerging nations produce enormous amounts of construction and demolition trash. Recycling enables the use of that space for other beneficial purposes as the disposal of this waste concrete necessitates a sizable area. The current thesis work's goal is to identify the strength properties of recycled aggregate for use in reinforced concrete construction. Reusing waste concrete entails breaking, crushing, and removing contaminated and irrelevant elements from existing concrete.

1.3 Problem Statement

Every year millions of tons of demolished concrete is generated in the world, when such amount of waste is generated it needs to be dumped which required a large area which is a big problem. To avoid such circumstances from the waste generated it is reused as filling in the subgrade of roads and in concrete production as an aggregate.

Dumping of solid waste is widely faced issue in the developed countries as well as in the developing countries. The utilization of demolished waste is the need of the day.

Utilizing waste materials like recycled aggregate in concrete can benefit the building industry's economic and environmental goals.

utilizing the concrete from the demolished buildings in the new construction to limit the use of natural aggregate and the depletion of natural coarse aggregate.

The main point of using demolished concrete back as an any construction material like coarse aggregate, fine aggregate and also sometimes uses as recycled cement, is to get rid of the problem of dumping it and also recycling od he demolition waste back in the construction is economically cheap.

Dumping of millions of tons of demolished waste not only required large area but also it is cost effective as well because transporting it into the dumping side is costly.

The demolished concrete is non-degradable waste and thus acres of land will be covered by the waste and thus the land will be of no use for the community or society and will create problems in the future.

So why not use the demolished waste as an recycled construction material and avoid the dumping problem and also the natural resource from which the construction materials come will last long and thus the depletion of natural resources will be minimize

1.4 Objective

- To compare and measure the compressive strength, flexure strength, and tensile strength of plastic or fresh concrete with green concrete utilizing various recycled aggregate percentages, such as 25, 50%, and 100%.
- Will also observed the workability of the green concrete with water cement ratio kept constant.
- We will observe to which extent the recycled aggregate can be effective in the new construction.

- By using different chemical substances along with cement, we will check how much strength they get when the specimen is constructed from 100% recycled aggregate.
- Will check the specimen sustainability to environmental effects.

1.5 Significance of Study

The project conducted to use demolished concrete aggregate can provide significant advantages to society and will help understand that how and where we can use demolished concrete as an aggregate.

The study of using demolished concrete can help the construction industry in the economical way as the demolished concrete aggregate can be available cheap with respect to the natural aggregate.

Also dumping of such large amount of concrete required a lot of transport and large area where this could be dumped so by recycling it in different construction projects this issue of dumping could be solved.

The study will also help that by using the recycled aggregate can help to reduce the environmental impacts of the construction industry on the environment.

The study will help many construction industries to use demolished concrete aggregate back in new construction and will help understand its effects in the fresh concrete.

1.6 Organization of thesis

The proposition is divided into five sections. A short thought regarding the parts is as per the following:

1.6.1 Chapter 1: Introduction

With every passing day the need for new constructions in the society is increasing rapidly. As aggregate is an important member of the concrete paste the utilization of the natural resources is growing towards its depletion. We focus on the use of demolished concrete waste as a recycled aggregate in the new construction material and to see how it effect the overall property of the mix its strength workability sustainability and much more related properties and to see the effect of using demolished concrete on the society and on industrial economy.

1.6.2 Chapter 2: Literature Review

Previously conducted research on the use of demolished concrete as an aggregate and the properties they attain, and using different methodologies, using different percentages of the demolished concrete aggregate, water cement ratio kept constant and by using certain chemicals like silica fume and fly ash, test results from the recycled aggregate concrete and analytical procedures they use are briefly explained in this section.

1.6.3 Chapter 3: Methodology / Experimental Work

The proposed set up for the project and different tests descriptions and their results are provided in this section. The proposed test procedures and their analysis is briefly explained in this section of the study and their detail discretion is being provided.

1.6.4 Chapter 4: Results and Deliberations

The results from different tests in the laboratory obtain of the concrete made of recycled aggregates and those made of fresh aggregates are being compared, during different stages of the project. Results and their graphs are given, and the detailed discussion of different outcomes are provided in this section of the study.

1.6.5 Chapter 5: Conclusion and Recommendation:

The synopsis of this project and the conclusions abstracted, and different recommendations made are put forward in this section of the study.

Chapter 2
Literature Review

2.1 General

Recycled concrete and masonry materials are combined to create blended recycled aggregates (MRA). Compared to herbal aggregates, these types of aggregates are less strong and better at absorbing water. So, compared to concrete made with natural materials, concrete made with recycled aggregates uses less electricity. The mechanical qualities of this concrete are improved, and the environmental problem caused by these waste metal wires is resolved, by incorporating metal fibres collected from waste tires inside the concrete with recycled aggregates. In this study, the effects of recycled metal fibres on the mechanical properties of regular concrete and concrete that contains recycled materials are examined. Also investigated the role of fibres in reducing the thickness of concrete pavement. The alternate proportion of natural coarse aggregates when combined with these aggregates is between 0 and 100%, with the fibre percentage falling between 0.5 and 1% of the total volume of the concrete. The manufacturing of structural concrete can be achieved by 50% replacement of aggregates by recycled aggregates and recycled fibres, according to fundamental effects. the thickness of concrete pavement is also reduced by eight and sixteen percent, respectively, by adding recycled fibres at 0.5 and 1% of the concrete quantity (Ahmadi, M. Farzin, Hassani A, & Motamedi. M, 2017).

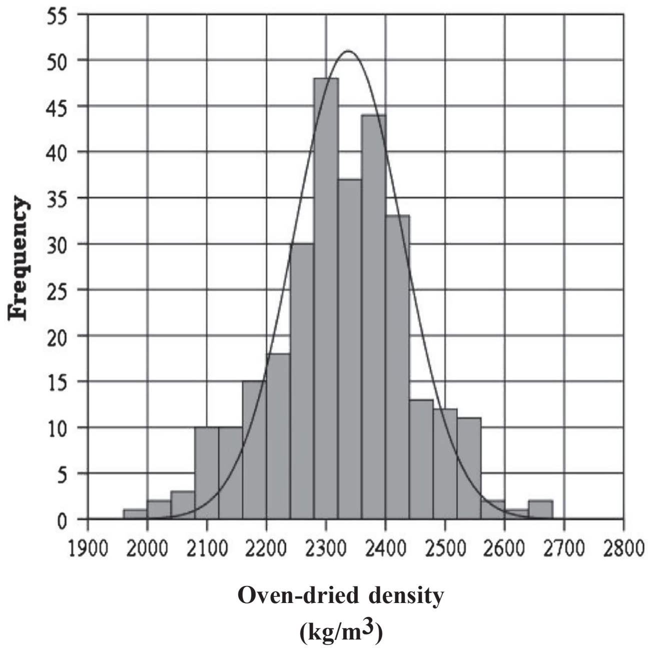
The report presents a comparative examination of the experimental findings regarding the properties of freshly poured and fully cured concrete with various replacement ratios of natural and recycled coarse aggregate. Waste concrete from precast concrete columns and laboratory test cubes was crushed to create recycled aggregate. Three different types of concrete mixtures have been tested: concrete that is entirely composed of natural materials (NAC), which served as a control, and concrete that is 50% and 100% made of natural, high-quality, and recycled coarse aggregate. For testing the essential properties of hardened concrete, 99 specimens had been created. The study also provides load testing of reinforced concrete beams made from the researched concrete kinds. Recycled aggregate concrete (RAC) performed best overall and did not significantly deviate from the performance of conventional concrete in these experimental experiments, regardless of the substitution ratio. However, for this to be accomplished, it is crucial to utilize the best recycled concrete coarse mixture and to adhere to the specific guidelines for the design and production of this new type of concrete (Malešev , M. Radonjanin , & Marinković. S, 2010).

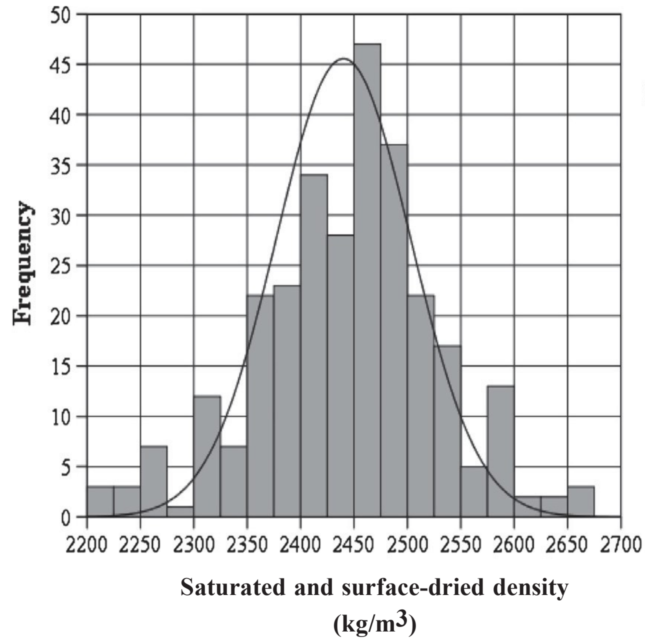
Recycling building waste as aggregate could be a crucial step toward attaining sustainability in concrete construction, given the global rise in construction and demolition. For usage in actual practice, however, a precise process for recycling construction and demolition (C&D) waste in concrete is required. The issues associated with using C&D wastes as recycled aggregate (RA), such as a weak interfacial transition zone, high water absorption, and the existence of microcracks, are reviewed in this work. Techniques for reducing these flaws through a variety of therapies have been published. The strengthening of attached mortar (AM) methodology, which is also more affordable, eco-friendly, and sustainable, is superior than removing AM, the authors conclude after analysing all treatment options. A more effective and environmentally friendly strategy for enhancing the characteristics of recycled aggregates is the use of nanomaterials and pozzolana in combination with various mixing techniques and the use of bio cement (Mistri A, Bhattacharyya S, K. Dhami, & N. Mukhe, 2020).

Environmental stability is a major worry as landfills fill up with an increasing volume of used tires and building debris. In order to encourage sustainable construction practices, researchers and policymakers are exploring for ways to reuse and reduce these waste materials. Therefore, the future sustainability of the building industry is affected using recycled coarse aggregate (RCA) and breadcrumbs of rubber (CR) made from scrap tires. This study examines how RCA, CR, and polypropylene (PP) Fibers work together to affect the fibers' mechanical and physical characteristics. In addition, it is investigated how reinforced concrete (RC) FR3C rays respond to flexural forces. RC samples 150mm x 200mm x 1500mm (W x D x D) are prepared for a set of fourteen measurements and put to the test. There are several possible combinations, with the RCA content and fiber fixed at 30% and 0.5%, respectively, and the CR content and steel ratio as variables (5% and 10% and 0.59% and 1.60%). The experimental study's findings show that adding CR and PP fibers to concrete improved its short- and long-term mechanical qualities. Concrete beams with 30% RCA, 5% CR, and 0.5% PP fiber shown enhanced ductility, toughness, and bending capacity. Additionally, the analysis demonstrates that the flexural capacity of FR3C beams with various reinforcement ratios cannot be determined using the current codes and design guidelines. Overall, this study demonstrates a novel method for producing sustainable concrete that is cleaner. (Shahjalal, 2020)

In this study, recycled concrete aggregate (RCA) from diverse sources is used to assess the capacity of producing concrete with predetermined performance (in terms of mechanical strength). This was accomplished by combining concrete created in a lab with prefabricated industry scraps. Three strength ranges—15–25 MPa, 35–45 MPa, and 65–75 MPa—were used to evaluate the capacity for self-replication. The created mixtures made an effort to mimic the PC's strength. Only full replacement (100%) of coarse recycled concrete aggregates (CRCA) with coarse natural aggregate (CNA) was evaluated. The findings demonstrate that there were no appreciable changes in mechanical properties or durability between aggregates from regulated sources and aggregates from prefabricated spits at the maximum level of goal power. Additionally, the usage of medium or high strength SCs significantly reduces performance losses brought on by RA integration (D, Pedro; J, de Brito; L, Evangelista, 2014).

Arising from a systematic, as opposed to narrative, literature review of 236 publications published over a period of 38 years from 1977 to 2014, the paper examines the factors affecting the physical, chemical, mechanical, permeation and compositional properties of recycled aggregates sourced from construction and demolition waste, intended for concrete production. Classifications based on their composition and contaminants have been studied. The data were collectively subjected to statistical analysis and a performance-based classification, mainly for use in concrete construction, is proposed. The results allowed producing a practical means of measuring the quality of recycled aggregates, which can be used to produce concrete with predictable performance. (Silva, 2014)


Frequency
Oven-dried density
(kg/m3)


Frequency
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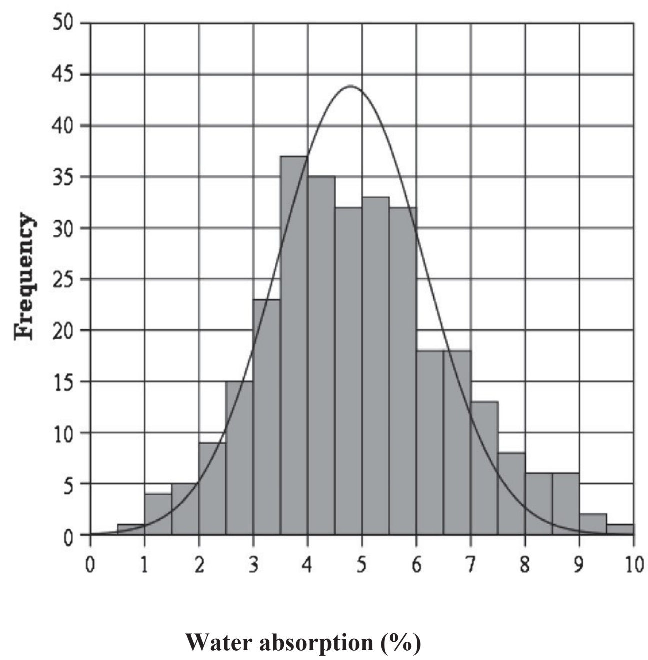
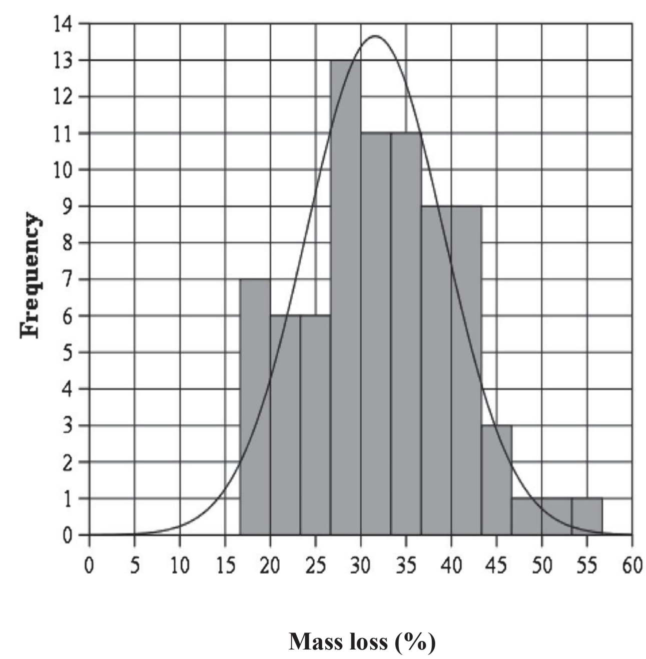
(kg/m3)


Frequency
Water absorption (%)


Frequency
Mass loss (%)

In recent years demolished concrete waste handling and management is the new primary challenging issue faced by the countries all over the world. It is very challenging and hectic problem that has to be tackled in an indigenous manner, it is desirable to completely recycle demolished concrete waste in order to protect natural resources and reduce environmental pollution. In this research paper an experimental study is carried out to investigate the feasibility and recycling of demolished waste concrete for new construction. The present investigation to be focused on recycling demolished waste materials in order to reduce construction cost and resolving housing problems faced by the low income communities of the world. The crushed demolished concrete wastes is segregated by sieving to obtain required sizes of aggregate, several tests were conducted to determine the aggregate properties before recycling it into new concrete. This research shows that the recycled aggregate that are obtained from site make good quality concrete. The compressive strength test results of partial replacement and full recycled aggregate concrete and are found to be higher than the compressive strength of normal concrete with new aggregate (Asif Husain, 2013).

Chapter 3
Methodology / Experimental Work

3.1 General

In this chapter, we will discuss materials used in making a concrete sample like we use demolish concrete as partially replacement for coarse aggregate in concrete sample with different percentages of 0%, 25%, 50% and 100% and then the experiments performed on the concrete samples in detail, along with the methodology employed. We will also cover the preparation of the Concrete samples with demolish concrete and highlight some of their key characteristics.

3.2 Materials Used

Following the acceptance of samples and the positive results of preliminary tests, all of the materials needed for this experimental research will be purchased from local vendors. According to ASTM standards, all testing will be performed.

3.2.1 Demolish Concrete

Demolished concrete refers to the concrete material that has been broken down or removed during the process of demolition. It is the result of breaking apart structures, buildings, or any other construction made of concrete. When these structures are no longer needed, outdated, or require replacement, the concrete is demolished or taken apart. Demolished concrete can vary in size and shape, depending on the specific demolition method used. It can range from large chunks of concrete to smaller fragments or even pulverized pieces. The demolished concrete may include various components, such as cement, sand, gravel, and any reinforcing materials like steel bars or mesh that were embedded within the concrete.

Demolished concrete has the potential to be a valuable resource as it can be recycled and used as aggregate for new concrete production. Recycling demolished concrete helps reduce the need for extracting new raw materials and can contribute to environmental sustainability.

We use demolished concrete as a coarse aggregate in concrete samples. We collect demolished concrete whose size is more than 4.75mm.

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Figure 3.1 Sample of Demolished Concrete

3.2.2 Cement

A key component of construction, cement is used in many different types of constructions all around the world. It is a fine powder that, when combined with water and other substances, serves as a binding agent. Portland cement, the most popular kind of cement, is created by heating a mixture of clay, limestone, and other minerals at high temperatures. Cement comes in a variety of varieties, including Portland Cement, Blended Cement, Rapid Hardening Cement, White Cement, and Sulphate Resistant Cement. The most common types of ordinary Portland cement (OPC), Type I or Type I/II, are used to make concrete.. OPC provides a balance between cost, availability, and desired strength characteristics, making it suitable for a wide range of construction applications. Cement offers several advantages in construction. It provides strength and durability to structures, allowing them to withstand heavy loads and harsh environmental conditions. Cement is versatile, allowing for various design possibilities, and it exhibits fire resistance, ensuring the safety of buildings.

Figure 3.2 Ordinary Portland cement

3.2.3 Coarse Aggregates

Coarse aggregate refers to particles sized between 4.75mm and 37.5mm used in the production of concrete. In simple words those particles which retain on 4.75mm sieve I known as coarse aggregate. It is one of the main components that make up the aggregate mixture, along with fine aggregate (such as sand) and cement. Coarse aggregate typically consists of materials like crushed stone, gravel, or recycled concrete. The purpose of course aggregate in concrete is to provide strength, stability, and bulk to the mixture. The larger particles fill the gaps between the fine aggregates and cement paste, forming a solid framework. This framework enhances the mechanical properties of the concrete, including its load-bearing capacity and durability.

Figure 3.3 Coarse aggregate sample

3.2.4 Fine aggregate

An aggregate passing over 4.75 mm sieve, is known as fine aggregate. Fine aggregates may be classified into the following types.

- Natural sand, resultant as of expected collapse of rocks
- Crumpled rock soil, got by squeeze of solid rock.
- Crumpled grit sand, found through squeeze of ordinary grit.

Fine aggregates are an essential component in the production of concrete, working alongside coarse aggregates and cement. Composed of small particles such as sand or crushed stone dust, fine aggregates play a crucial role in filling the gaps between coarse aggregates and cement paste. They act as a lubricant, allowing for better workability and flow of the concrete mixture during construction. The primary function of fine aggregates is to enhance the cohesion and bonding properties of the concrete. When mixed with cement paste, the fine particles surround and coat the surfaces of the coarse aggregates, creating a dense and compact matrix. This matrix contributes to the strength, durability, and overall performance of the concrete structure.

Figure 3.4 Sample of Fine Aggregate (Sand)

3.2.5 Water

Water is a crucial element in concrete. It initiates the hydration process, allowing the cement particles to bind together and form a solid structure. The amount of water used affects the workability and strength of the concrete. Adequate water content is necessary for proper compaction and shaping of the mixture during construction.

However, excessive water or inadequate curing can lead to weakened concrete. Balancing the water-cement ratio and implementing appropriate curing practices is essential for achieving durable and strong concrete structures.

3.3 Mix Design

The process of figuring out the ratios of different ingredients that will result in a concrete mixture with the appropriate qualities is known as mix design. It entails choosing the right components, such as cement, coarse and fine aggregates, water, and occasionally admixtures, and calculating their appropriate ratios to produce concrete with the desired strength, workability, durability, and other specified properties..

During mix design, tests and calculations are performed to determine the optimal proportions of each ingredient. These tests may include trials with different combinations of materials, measuring the specific gravity of aggregates and workability of the fresh concrete etc.

3.4 Preliminary Tests

We conduct various tests and experiments to determine the optimal proportions of materials for concrete production. During experimental work, different combinations of cement, aggregates (coarse and fine), water, and demolished concrete are tested. These materials are mixed in different proportions to create trial mixes. The mixes are then subjected to various tests to evaluate their properties.

3.4.1 Sieve Analysis for Fine Aggregates (ASTM C 117)

Sieve analysis is a process used to determine the particle size distribution of granular materials. It involves passing a sample through a series of sieves with different mesh sizes to separate the particles based on their sizes. For conducting a sieve analysis specifically for fine aggregates, the ASTM code is ASTM C117 and for conducting a sieve analysis specifically for coarse aggregates, the ASTM code is ASTM C136.

We start by obtaining a sample of the fine aggregate according to the sampling procedure specified in the ASTM standard and dried the sample in an oven at a temperature of 110 ± 5°C (230 ± 9°F) for 24 hours. We Weigh the dried sample accurately and started preparing a nest of sieves by stacking them in descending order of sieve opening sizes, with the finest sieve at the bottom as like #4, #8, #16, #30, #50, #100, #200 and we kept a pan at the bottom of the stack to collect the finest particles.

We placed the entire sample of fine aggregate into the top sieve and covered it. We Shaked the sieves using a mechanical sieving device for 10 minutes to ensure complete separation of particles based on size. We carefully removed each sieve from the stack, one at a time, and weighed the material retained on each sieve and calculated the cumulative percentage passing and the cumulative percentage retained for each sieve.

Apparatus and equipment used for sieve analysis of fine aggregate are as follows:

- Sieves
- Oven
- Balance
- Spatula
- Fine Aggregate sample

Figure 3.5 Sieve Analysis for Fine Aggregate

3.4.2 Sieve Analysis for Coarse Aggregates (ASTM C 136)

After completion of sieve analysis for fine aggregate we start by obtaining a sample of the coarse aggregate according to the sampling procedure specified in the ASTM standard and dried the sample in an oven at a temperature of 110 ± 5°C (230 ± 9°F) for 24 hours. We weigh the dried sample accurately and started preparing a nest of sieves by stacking them in descending order of sieve opening sizes, with the the largest sieve at the top as like #3/2", #1", #3/4", #3/8", #4 and we kept a pan at the bottom of the stack to collect the finest particles.

We placed the entire sample of coarse aggregate into the top sieve and covered it. We Shaked the sieves manually for 10 minutes to ensure complete separation of particles based on size. We carefully removed each sieve from the stack, one at a time, and weighed the material retained on each sieve and calculated the cumulative percentage passing and the cumulative percentage retained for each sieve.

Apparatus and equipment used for sieve analysis of coarse aggregate are as follows:

- Sieves
- Mechanical Sieve Shaker
- Oven
- Balance
- Spatula
- Coarse Aggregate sample

Figure 3.6 Sieve Analysis for Coarse Aggregate

3.4.3 Water Absorption Test for Coarse Aggregates (ASTM C127)

Water absorption refers to the capacity of a material, such as coarse aggregates used in concrete, to absorb water. In the context of aggregate testing, the water absorption test provides an indication of the aggregate's ability to retain moisture.

We Start by taking a sample of coarse aggregate and ensured it was clean and free from dust or debris. We preheated the oven to a temperature of 230°F (110°C) and determined the weight (W1) of the clean, dry empty pan. We placed the aggregate sample in the pan and completely immersed it in water for 24 hours. We removed the saturated aggregate from water and allowed it to drain for a few minutes and determined the weight (W2) of the saturated aggregate and pan then we placed the saturated aggregate in the oven and kept it for

24 hours. After 24 hours we removed the sample from oven and find out the weight (W3) of the dry aggregate and pan. We used the following formula to calculate the water absorption for coarse aggregate:

Water absorption = [(W2 - W3) / (W3 - W1)] × 100% .... Equation 3.1

Equipment and materials for water absorption test of coarse aggregate:

- Coarse aggregate sample
- Container
- Drying oven
- Water bath
- Tamping rod
- Balance
- Absorbent towels

Figure 3.7 Water Absorption for Coarse Aggregates

3.4.4 Specific Gravity Test for Coarse Aggregates (ASTM 127)

Specific gravity is a property used to measure the density of a material relative to the density of water. In the context of aggregates, specific gravity provides an indication of the aggregate's relative density compared to water. It is determined by comparing the weight of a given volume of the material to the weight of an equal volume of water.

We Start by taking a sample of coarse aggregate and ensured it was clean and free from dust or debris. We preheated the oven to a temperature of 230°F (110°C) and determined the weight (W1) of the clean, dry empty pycnometer. We filled the pycnometer with aggregate and determine the weight (W2) of the aggregate. After that we immersed the pycnometer in water and allow it to remain for 24 hours. We removed the pycnometer from water after 24 hours, drained the excess water, and determined the weight (W3) of the saturated aggregate and pycnometer. We placed the saturated aggregate in the oven and kept it in oven for 24 hours to dry and found out the weight (W4) of the dry aggregate.

We used the following formula to calculate the specific gravity for coarse aggregates.

S. G = [(W2 - W1) / (W4 - W1)] × (W3 - W1) / (W2 - W3) ………. Equation 3.2

Apparatus and equipment used for the test are as follows:

- Coarse aggregate sample
- Pycnometer
- Water bath
- Drying oven
- Balance

Figure 3.8 Specific Gravity of Coarse Aggregates

3.4.5 Water Absorption Test for fine Aggregates (ASTM C127)

We Start by taking a sample of fine aggregate and ensured it was clean and free from dust or debris. We preheated the oven to a temperature of 230°F (110°C) and determined the weight (W1) of the clean, dry empty pan. We placed the aggregate sample in the pan and completely immersed it in water for 24 hours. We removed the saturated aggregate from water and allowed it to drain for a few minutes and determined the weight (W2) of the saturated aggregate and pan then we placed the saturated aggregate in the oven and kept it for 24 hours.

After 24 hours we removed the sample from oven and found out the weight (W3) of the dry aggregate and pan. We used the following formula to calculate the water absorption for fine aggregate:

Water absorption = [(W2 - W3) / (W3 - W1)] × 100% .... Equation 3.3

Equipment and materials for water absorption test of coarse aggregate:

- Fine aggregate (Sand) sample
- Container
- Drying oven
- Water bath
- Tamping rod
- Balance
- Absorbent towels

Figure 3.9 Water Absorption for Fine Aggregates

3.4.6 Specific Gravity Test for Fine Aggregates (ASTM C127)

We Start the experiment by taking a sample of fine aggregate and ensured that sample of fine aggregate was clean and free from dust or debris. We preheated the oven to a temperature of 230°F (110°C) and determined the weight (W1) of the clean, dry empty pycnometer. We filled the pycnometer with aggregate and determined the weight (W2) of the aggregate.

After that we immersed the pycnometer in water and allowed it to remain for 24 hours. We removed the pycnometer from water after 24 hours, drained the excess water, and determined the weight (W3) of the saturated aggregate and pycnometer. We placed the saturated aggregate in the oven and kept it in oven for 24 hours to dry and found out the weight (W4) of the dry aggregate. After collecting all the required data,

We Used the following equation to find the specific gravity for fine aggregates.

$S.G = [(W2 - W1) / (W4 - W1)] \times (W3 - W1) / (W2 - W3)$ ………. Equation 3.4

Apparatus and equipment used for the test are as follows:

- Pycnometer
- Water bath
- Drying oven
- Balance
- Fine aggregate (Sand) sample

3.4.7 Shape Test (ASTM D4791)

The shape of aggregates plays a crucial role in the performance of concrete and asphalt mixtures. The shape refers to the geometrical characteristics of individual particles, including their form, angularity, and surface texture. The shape of aggregates can affect workability, strength, stability, and the overall performance of the finished product. The shape test for aggregates is conducted to assess their angularity and texture, particularly in relation to the requirements of specific construction applications. While there is no specific ASTM code for the shape test, various methods, and standards, such as ASTM C1252 and ASTM D4791, are used to evaluate aggregate shape.

For shape test of coarse aggregate, we took a sample of 1000gm of coarse aggregate and flakiness and elongation sieves we pas the aggregates from the flakiness and elongation sieves. We Inspect each particle individually and classified them as "flat," "elongated," or "not flat or elongated”.

A particle was considered flat if its ratio of thickness to average width was less than or equal to 0.5 and a particle was considered elongated if its ratio of length to average width was greater than 0.5.

Equipment and materials used for the shape test of coarse aggregate:

- Coarse aggregate sample
- Balance

- Sieves
- Pan

Figure 3.10 Flakiness and Elongation of Aggregates

3.4.8 Soundness Test (ASTM C88)

Soundness of aggregates refers to their ability to resist volume changes or disintegration caused by the presence of potentially harmful constituents such as clay, silt, or certain types of minerals. The soundness of aggregates is crucial in ensuring the long-term durability and performance of concrete and other construction materials. Aggregates that are not sound may undergo expansion, cracking, or disintegration when subjected to moisture changes, which can lead to structural problems. The soundness test for aggregates, as specified by ASTM C88, titled as "Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate." is a method used to evaluate their resistance to volume changes. This test involves immersing the aggregate sample in a saturated solution of either sodium sulfate or magnesium sulfate and subjecting it to cycles of wetting and drying. The repeated exposure to the solution and subsequent drying in an oven replicates the effects of moisture fluctuations in real-world conditions.

For soundness test of aggregate, we needed to have a solution of Na2SO4, so we took a sample of Na2SO4 and mix it with water. The solution was prepared, and we took a sample of aggregate we put the aggregate sample in the prepared mixture and kept the pan that was filled of the aggregate sample and mixture in an oven at a temperature of 110°C for 24 hours but made it sure that the sample was fully immersed in the mixture. After keeping the sample in oven for 24 hours we removed the sample from oven and allowed them tool cool it at room temperature. We examined the samples for any signs of disintegration or decomposition and compared the appearance of the samples to the original condition of the aggregate to get the degree of disintegration or decomposition.

Figure 3.11 Soundness Test for Aggregates

The apparatus, equipment, and materials used in a soundness test for aggregates includes:

- Coarse aggregate samples
- Na2SO4
- Soundness test apparatus
- Water bath
- Sample containers
- Oven
- Balance
- Graduated cylinder

3.4.9 Impact Value Test (ASTM C 131)

The impact value of aggregates is a measure of their resistance to impact or sudden shock. It evaluates the toughness and durability of the aggregates. The impact value indicates the ability of aggregates to withstand dynamic loading and the potential for breakage or degradation under impact force. The impact value test for aggregates involves subjecting a representative sample to impact forces in a specialized testing apparatus. There is no specific ASTM code for the impact value test, but we used ASTM C125 code for the test, although similar tests such as the Aggregate Impact Value (AIV) test, as per standards like BS 812: Part 112 and EN 1097-2, are commonly conducted.

The impact value test was performed to find out the crushing value in percentage. We start the procedure from obtaining a sample of 800 grams of coarse aggregates and passing it from sieve #9.5mm. We Placed the passed aggregate sample in the impact value apparatus and compact it uniformly by dropping the hammer 25 times from specified height. The sample which was compacted by blowing it 25 times with dropping hammer was passed from sieve #3.35mm. The sample which was passed from sieve #3.35 was weighted. We used the following formula to find the impact value in percentages.

Aggregate Impact Value (AIV) = Wc/Wb*100

Wc = Weight of the fraction passing through the sieve #3.35mm (in grams)

Wb = Original weight of the aggregate sample passed from sieve #9.5mm (in grams).

Apparatus and materials used in an impact value test for coarse aggregates include:

- Impact testing machine (ASTM designation: D5874)
- Sample of aggregates
- Sieve #9.5mm and #3.35
- Oven
- Balance
- Hammer
- Pan

Figure 3.12 Impact Value Test of Aggregates

3.5 Water Cement ratio

The water-cement ratio is a fundamental parameter in concrete mix design that determines the amount of water relative to the amount of cement used in the mixture. It is expressed as the ratio of the weight of water to the weight of cement in the mix. The water-cement ratio plays a crucial role in the workability, strength, durability, and overall performance of concrete. A lower water-cement ratio generally leads to stronger and more durable concrete, but it can reduce workability. We use the following table of ACI standards to select proper water cement ratio for a compressive strength of 3000psi which is 0. 68.

Table 3.1 ACI Standard Table for Water Cement Ratio

28-Day Compressive Strength in MPa (psi)	Water-cement ratio by weight	
	Non-Air-Entrained	Air-Entrained
41.4 (6000)	0.41	-
34.5 (5000)	0.48	0.40
27.6 (4000)	0.57	0.48
20.7 (3000)	0.68	0.59
13.8 (2000)	0.82	0.74

3.6 Batching of Materials

Batching is the process of measuring and combining the ingredients of a concrete mix. The accuracy of batching is critical to the quality of the concrete. There are two main methods of batching: volume batching and weight batching.

In volume batching, the ingredients are measured by volume. This is the most common method of batching for small projects. However, it is not as accurate as weight batching. In weight batching, the ingredients are measured by weight. This is the most accurate method of batching and is required for large projects.

So, for our project we used weight batching we calculated the quantities of fine coarse aggregate, demolished concrete, and cement for 1:2:4 mix design of concrete and used 0.68 water cement ratio to get water quantity in liters.

Calculation for batching of materials is as follows:

Concrete mix ratio: 1:2:4

Concrete volume: 0.214 m3

Water-cement ratio: 0.68

Cement

Cement = 0.214 m3 * 1 / (1 + 2 + 4) = 0.03 m3

Cement = 0.03 m3 * 1440 kg/m3

Cement = 43.8 kg

Coarse Aggregate

Coarse Aggregate = 0.214 m3 * 4 / (1 + 2 + 4) = 0.12 m3

Coarse Aggregate = 0.12 * 1575 = 192.6 kg

Demolished Concrete 25%

Demolished Concrete 25% = (192.6 *25)/100 = 48.15 kg

Demolished Concrete 50%

Demolished Concrete 50% = (192.6 *50)/100 = 96.3 kg

Fine Aggregate

Sand = 0.214 m3 * 2 / (1 + 2 + 4) = 0.06 m3

Sand = 0.06 m3 * 1700 kg/m3 = 103.4 kg

Water

W/C = 0.68

W/43.8 = 0.68

W = 29.8L

The quantities used for each corresponding sample that contains different percentages of demolished concrete are as shown in table below:

Table 3.2 Quantities of Material Used for Concrete Samples

No	Ratio	Cement (kg)	Water (lit)	Fine agg (kg)	Course agg (kg)	Demolished concrete (kg)
1	1:2:4	43.8	29.8	103.5	192.6	00

2	1:2:4	43.8	29.8	103.5	144.45	48.15
3	1:2:4	43.8	29.8	103.5	96.3	96.3
4	1:2:4	43.8	29.8	103.5	00	192.6

3.7 Experimental Work

After all the preliminary tests on materials used in concrete and batching of materials, we start experimental work on the prepared concrete.

3.7.1 Slump Test for Workability (ASTM C143)

The slump test is used to measure the workability of fresh concrete by assessing its consistency and flowability. It provides a quick and simple indication of how easily the concrete can be placed, compacted, and shaped on-site.

We start by preparing concrete using concrete mixer and a ratio of 1:2:4 and then moisten the inside surface of the slump cone and place it on a non-absorbent base plate. We filled the cone from the prepared concrete in three equal layers, each approximately one-third of the cone's height and used tamping rod to compact each layer by giving 25 tamping blows.

After the final layer is tamped, we stroked off the excess concrete from the top of the cone using blade and ensured a smooth and flat surface We lift the cone vertically, steadily and without any sudden jerks and measured the difference between the height of the cone with height of concrete using measuring tape and we noted the value.

Figure 3.13 Slump Test for Concrete

3.7.2 Casting and Curing of Samples

Casting and curing are integral processes in concrete production that serve a vital purpose in ensuring the strength, durability, and overall quality of the material. Casting involves carefully preparing and placing the concrete mixture into molds or formwork, while curing refers to the maintenance of proper moisture and temperature conditions for an appropriate duration to facilitate hydration and development of desired concrete properties. Through effective casting and curing, the concrete gains strength, minimizes shrinkage, enhances durability, and attains the necessary characteristics for its intended structural or functional applications.

We start preparing concrete samples using the ratio 1: 2: 4 in which 1,2 and 4 shows quantity of cement, fine aggregate (sand) and Coarse aggregate (Demolished Concrete) respectively.

After preparing the concrete in required amount for testing samples we start curing the samples for 28 days and then we start testing it.

5

Figure 3.14 Samples Before and After Curing

3.7.3 Compressive Strength Test (ASTM C39)

Compressive strength is a crucial property that measures the ability of a material, such as concrete, to withstand compressive forces or loads without failing or deforming. It is an essential parameter in structural engineering as it determines the maximum load that a material can bear under compression. Compressive strength tests are conducted to accurately determine the compressive strength of materials like concrete. The test involves subjecting cylindrical or cubic specimens to increasing loads until they fracture or fail.

After curing the sample for 28 days we kept the out the sample at room temperature for 24 hours to make it ready for compressive strength testing. We start setting and calibrating the UTM according to the procedure. We start the UTM and apply a continuous and uniform load at a specified rate failure occurs. We Continued applying the load until the specimen fractured completely. We monitored the load and observed the behavior of the specimen during the test.

We noted the value of failure load and used the following formula to find the compressive strength.

Compressive strength = W/A ………. Equation 3.5

Where:

C = Strength of Concrete (Compressive strength)

W =Load.

A = Area

Equipment's and Materials used in experiment are as follows:

- Sample
- Compression testing machine (Universal Testing Machine)
- Measuring Tape
- Spatula etc

Figure 3.15 Compressive Strength Test

3.7.4 Flexure Strength Test

Flexural strength is a critical mechanical property that characterizes a material's ability to resist bending or deformation when subjected to applied loads. In the context of materials like concrete, flexural strength reflects their capacity to withstand external forces and maintain structural integrity under bending stresses.

The flexural strength test is conducted to determine the maximum bending moment or stress a material can withstand before fracturing or failing under bending loads. This test involves subjecting a beam-shaped specimen to increasing loads at its midpoint until it reaches failure.

For doing flexural strength test we needed beam samples of the concrete prepared by using 1: 2: 4 so we took the samples of concrete that were already prepared and cured for 7, 14 and 28 days. We start setting and calibrating the UTM according to the procedure and placed the cured specimen horizontally making sure it is centered and leveled. We applied the load to the specimen at a constant rate until failure occurs. The load was applied at the midpoint between the two supports using rounded nose bearing strip.

During the test, we record the applied load as well as the maximum load at which the failure occurs and corresponding mid-span deflection of the specimen.

After the test, we calculate the flexural strength of the sample using the following formula:

Flexural Strength = 3PL / (2bd^2) ………. Equation 3.6

Where:

P = Load at failure (maximum applied load)

L = Support span length

b = Width of the specimen

d = Depth of the specimen

Figure 3.16 Concrete Sample Before and After Flexural Test

Equipment’s and Materials used in experiment are as follows:

- Sample
- Flexural testing machine (Universal Testing Machine)
- Measuring Tape

3.7.5 Split Tensile Strength Test

Split tensile strength is a mechanical property that measures the ability of a material, such as concrete, to resist tensile forces perpendicular to its axis. In the case of concrete, which is generally strong in compression but weak in tension, the split tensile strength test provides valuable information about its ability to withstand tensile stresses. The split tensile strength test is a method used to determine the tensile strength of concrete by applying a splitting force perpendicular to the axis of a cylindrical specimen. During the test, the specimen is placed between two hardened platens, and a compressive load is applied along its axis. As the load increases, tensile stresses develop perpendicular to the axis, causing the specimen to crack and eventually split.

For split tensile strength test, we used the same prepared sample of ratio 1: 2: 4 that were cured for 7, 14 and 28 days. We followed the ASTM procedure and started the test by placing the concrete cylinder horizontally in Universal Testing Machine. We positioned the cylindrical samples between two loading platens and applied the load to the sample at a constant rate until failure occurs. The applied load was perpendicular to the axis of the sample, causing it to split along the diameter. We applied the loading until the sample fails and record the applied load and corresponding diametral deformation of the specimen.

For calculating split tensile strength, we use the following equation:

Split Tensile Strength = $2P / (\pi DL)$ ………. Equation 3.7

Where:

P = Load at failure (maximum applied load)

D = Diameter of the specimen

L = Length of the specimen

Equipment’s and Materials used in experiment are as follows:

- Sample
- Split tensile strength testing machine (Universal Testing Machine)
- Measuring Tape

Figure 3.17 Split Tensile Strength Sample Before and After

Chapter 4
Results and Discussion

4.1 General

This chapter is all about the results examined from the performed Preliminary test like sieve analysis of coarse and fine aggregates, water absorption of coarse and fine aggregates, specific gravity of coarse and fine aggregate and shape soundness and impact value of coarse aggregates as well as the results of compressive strength test, flexural strength test and split tensile strength test were expressed and discussion on partially and fully replacement of demolished concrete as coarse aggregate with different percentage has been made.

4.2 Preliminary Tests Results

We obtained results from the preliminary test like sieve analysis, water absorption, shape, soundness, and impact value on the material used for preparing concrete samples like coarse aggregate fine aggregate cement and demolished concrete before finding the mechanical properties of normal and modified concrete.

The overall results from the test are show and discussed below.

4.2.1 Sieve Analysis of Fine Aggregate Result

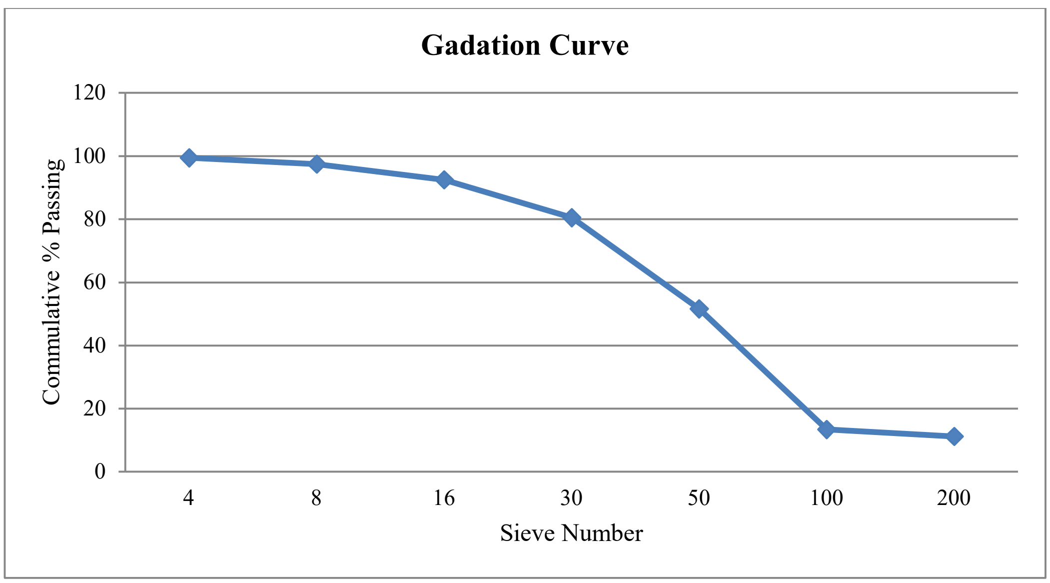
A total of 1000 grams of fine aggregate was taken for the sieve analysis. The results of the analysis, conducted using sieves with sizes of 4.75 mm, 2.36 mm, 1.18 mm, 0.6 mm, 0.3 mm, 0.15 mm, and 0.074 mm, revealed the particle size distribution of the fine aggregate sample. The amount of material retained on each sieve was determined as follows: 6 grams on the 4 sieve, 16 grams on the 8 sieve, 54 grams on the 16 sieve, 120 grams on the 30 sieve, 288 grams on the 50 sieve, 382 grams on the 100 sieve, and 22 grams on the #200 sieve. As well as the calculated fineness modulus of 2.5 indicates the overall fineness of the aggregate. The sieve analysis results show that this sample of sand is relatively fine. most of the particles are less than 0.15 mm in size

The following table shows all the results obtained and the graph shows gradation from the sieve analysis for fine aggregates.

Table 4.1 Results of Sieve Analysis for Fine Aggregates

Sieve number	Size (mm)	ASTM C33 Finer Limit	ASTM C33 Coarser Limit	Material retained (gm)	% Material retained	Cumulative % retained
4	4.75	100	95	6	0.6	0.6
8	2.36	100	80	16	1.6	2.2
16	1.18	85	50	54	5.4	7.6
30	0.6	60	25	120	12	19.6
50	0.3	30	5	288	28.8	48.4
100	0.15	10	0	382	38.2	86.6
200	0.074	5	0	22	2.2	88.8
			Total (gm)	888	Total	253.8
Total sample taken(gm) = 1000 gm					Fineness modulus	2.5

The following graph shows gradation from the sieve analysis for fine aggregate.



Graph 4.1 Gradation Curve for Sieve Analysis of Fine Aggregates

4.2.2 Sieve Analysis of Coarse Aggregate Result

The analysis included sieves with sizes of 37.5 mm (3/2 in), 25 mm (1 in), 19 mm (3/4 in), 9.5 mm (3/8 in), and 4.75 mm (No. 4) The results include the material retained on each sieve, expressed in grams, as well as the percentage of material retained, and the cumulative percentages retained and passing.

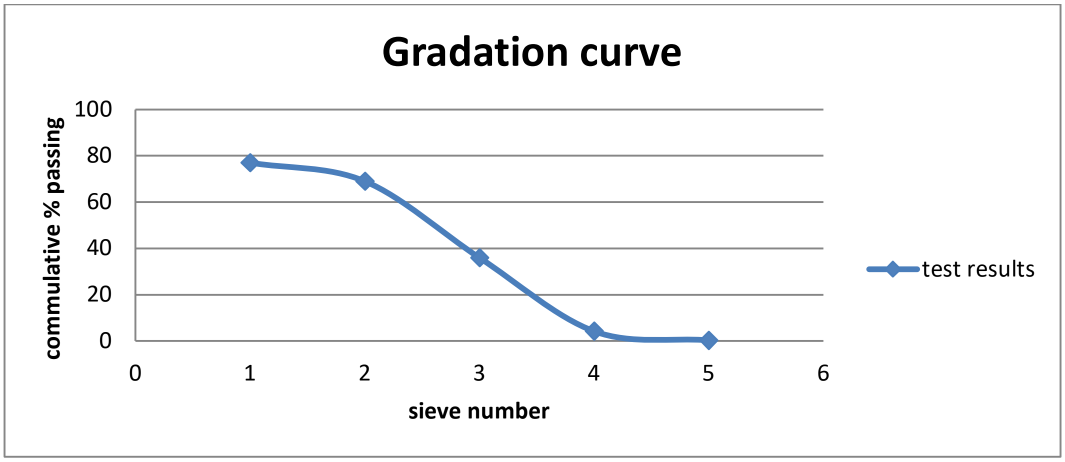
For the 37.5 mm (3/2 in) and 25 mm (1 in) sieves, no material was retained, resulting in 0 grams of material retained, 0% material retained, and 100% cumulative passing. Moving to the 19 mm (3/4 in) sieve, 76 grams of material were retained, accounting for 3.8% of the total sample. The cumulative percentage retained on this sieve was 3.8%, with a cumulative percentage passing of 96.2%. On the 9.5 mm (3/8 in) sieve, a significant amount of material, 1840 grams, was retained, representing 92% of the sample. This resulted in a cumulative percentage retained of 95.8% and a cumulative percentage passing of 4.2%. Finally, the 4.75 mm (No. 4) sieve retained 80 grams of material, equivalent to 4% of the sample. The cumulative percentage retained on this sieve was 99.8%, while the cumulative percentage passing was 0.2%. The total amount of material retained across all sieves was 1996 grams, while the total sample taken for the analysis was 2000 grams.

The following table shows all the results obtained and the graph shows gradation from the sieve analysis for coarse aggregates.

Table 4.2 Results of Sieve Analysis for Fine Aggregates

Sieve number	Size (mm)	ASTM C33 Finer Limit	ASTM C33 Coarser Limit	Material retained (gm)	% Material retained	Cumulative % retained	Cumulative % passing
3/2 in	37.5	100	100	0	0	0	100
1 in	25	100	100	0	0	0	100
3/4 in	19	90	100	76	3.8	3.8	96.2
3/8 in	9.5	20	55	1840	92	95.8	4.2
4 in	4.75	0	10	80	4	99.8	0.2
			Total (gm)	1996			
			Total sample taken (gm)	2000			

Gradation Curve for Sieve Analysis of coarse aggregate has been presented below:



Graph 4.2 Gradation Curve for Sieve Analysis of Coarse Aggregates

4.2.3 Water absorption

The moisture content of the sample was determined by taking a 1000-gram sample. The initial weight of the sample (w1) was recorded as 1000 grams, while the weight after drying (w2) was measured as 986 grams. The moisture content (M.C.) was calculated using the formula.

M.C. = (w1 - w2) / w1 * 100.

Substituting the values, we get

M.C. = (1000 - 986) / 1000 * 100

Resulting in moisture content of 1.40% indicates the amount of moisture present in the sample.

Table 4.3 Results for Water Absorption Test of Aggregates

Moisture Content	
Sample taken (gm)	1000
Column1	Column2
w1 (gm)	1000
w2 (gm)	986
M.C	w1-w2/w1*100
	1000-986/1000*100
M.C	1.40%

4.2.4 Shape Test Results

The test results showed that the aggregate had a flakiness index of 13.66% and an elongation index of 10.01%. These values indicate that the shape characteristics of the aggregate meet the specified requirements, as the combined index falls below the maximum limit of 35%. The total weight of the sample used for the test was 1000 grams. The following table shows all the results obtained from the shape test.

Table 4.4 Shape Test for Aggregates Results

Sieve no passing (mm)	Sieve no retained (mm)	Weight of friction say 200 particles (g) wt. A	Aggregate passed through flakiness gauge in (g)	Weight retained on flakiness gauge wt. (g) C	Aggregate passed from elongation gauge (g) D	Weight retained on elongation gauge (g) E
50	37.5	0	0	0	0	0
37.5	28	0	0	0	0	0
28	20	5244	239	5005	4892	113
20	14	2457	114	2343	2199	144
14	10	1346	609	737	499	238
10	6.3	953	404	549	179	370
6.3		10000	1366	8634		865
Flakiness Index			1366/10000*100 = 13.66		Total weight is 1000 grams	
Elongation Index			865/8634*100 = 10.01			
Max range for combined flakiness and elongation index is 35%						

4.2.5 Soundness Test Results

The soundness test of the aggregate, conducted according to ASTM C 88, involved determining the loss in weight due to exposure to sodium sulphate solution. The test results for two size ranges of the aggregate are as follows:

For the size range of 19 mm to 12.5 mm, the weight of aggregate passing through the sieve was 670 grams, and the weight passing through the 8 mm sieve was 3.3 grams. The weight retained on the 8 mm sieve was 666.7 grams. The actual loss percentage or soundness value for this size range was calculated as 3.3/670 * 100, resulting in a value of 0.493%. Similarly, for the size range of 12.5 mm to 9.5 mm, the weight of aggregate passing through the sieve was 330 grams, and the weight passing through the 8 mm sieve was 8.4 grams. The weight retained on the 8 mm sieve was 321.6 grams. The actual loss percentage or soundness value for this size range was calculated as 8.4/330 * 100, resulting in a value of 2.545%. To obtain the total actual loss percentage or soundness value, the individual values for both size ranges were added together, resulting in a value of 3.038%. In the soundness test, a sodium sulphate solution with a concentration of 215 g/l was used for the testing procedure. The following table shows all the results obtained from the soundness test.

Table 4.5 Soundness Test Results for Aggregates

Discription	Quantity	ASTM Standards	
Wt. of aggregate pass from 19~12.5 (mm)	670 (g)	100-90 (mm)	75 mm
Wt. of aggregate pass from 12.5~9.5 (mm)	330 (g)	90-75	63
Retained wt. on sieve no 8 mm (19~12.5)	666.7 g	75-63	50
Passing wt. on sieve no 8 mm (19~12.5)	3.3 g	63-37.5	31.5
Retained wt. on sieve no 8 mm (12.5~9.5)	321.6 g	37.5-19	16
Passing wt. on sieve no 8 mm (12.5~9.5)	8.4 g	19-9.5	8
Actual loss % or soundness value (19~12.5) mm	3.3/670*100 = 0.493	9.5-4.75	4
Actual loos % or soundness value (12.5~9.5) mm	8.4/330*100 = 2.545		
Total actual % loss or soundness value	2.545+0.493		
Na2So4 sample	215 g/l		

4.2.6 Impact Value Test

The aggregate impact value test, conducted in accordance with ASTM C 125, aimed to assess the impact resistance of the tested aggregate. A sample weighing 800 grams (W(a)) was used for the test. After the test, the weight of the sample retained on the 9.5 mm sieve (W(b)) was found to be 500 grams, while the weight of the sample passed through the 3.35 mm sieve (W(c)) was 118 grams. The average impact value was calculated using the formula (W(c)/W(b)) * 100, resulting in a value of 23.60%. According to the suggested values by ASTM, impact values ranging from 10% to 20% are considered strong, while values ranging from 20% to 30% are deemed satisfactory. In this case, the aggregate falls within the satisfactory range, indicating acceptable impact resistance.

The following table shows all the results obtained from the impact value test.

Table 4.6 Impact Value Test Results

S. No	Description	Calculations & Quantity (g)	
1	Weight of sample	W (a)	800
2	Weight of sample retained on 9.5 mm sieve	W (b)	500
3	Weight of sample passed through sieve 3.35 mm	W (c)	118
4	Average impact value in %	(Wc/Wb) *100	23.60%
ASTM suggested values in %		10 to 20	Strong
		20 to 30	Satisfactory
		Less than 10	Exceptionally strong

4.3 Experimental Work Results

The results that were obtained from all the experimental work on concrete like slump test, compressive strength test, flexure strength test and split tensile strength test are presented below.

4.3.1 Slump Test Results

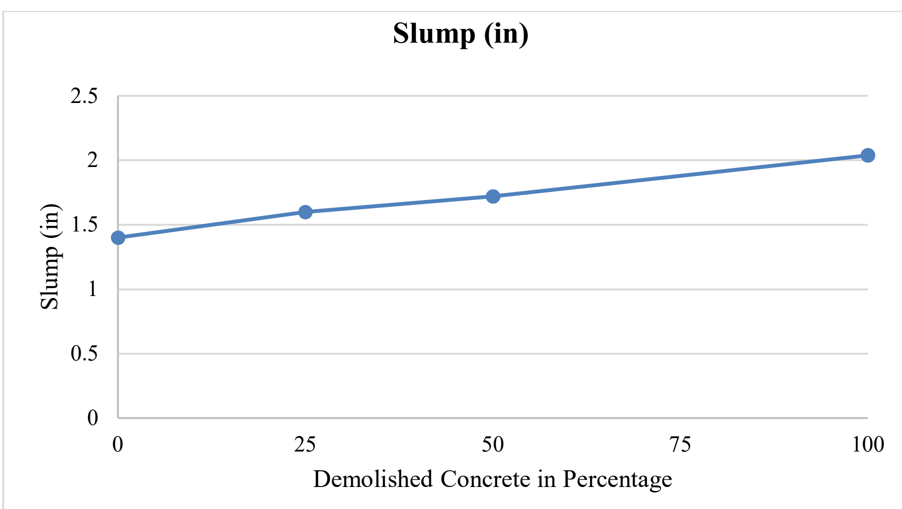
The results of slump tests conducted on four types of concrete samples labelled A1, A2, A3, and A4 were prepared using the same ratio of 01:02:04, indicating the proportions of cement, sand, and aggregate in the mix. The water-to-cement (w/c) ratio was consistent at 0.68. The results of the slump test reveal varying measurements for each specimen. Specimen A1, which contained no demolished concrete, exhibited a slump of 35 mm (1.4 inches).

The following Table and graph show all the results obtained from slump test on concrete.

Table 4.7 Slump Test Results of Concrete Samples

Specimen	Ratio	%age of demolished concrete	w/c ratio	Slump (mm)	Slump (in)
Normal Concrete	1: 2: 4	0	0.68	35	1.4
D-25 Concrete	1: 2: 4	25	0.68	40	1.6
D-50 Concrete	1: 2: 4	50	0.68	43	1.72
D-100 Concrete	1: 2: 4	100	0.68	51	2.04

As shown below in grapgh the slump of the concrete increased as the percentage of demolished concrete increased. This is because demolished concrete is more porous than normal aggregate, which makes the concrete more workable. The results of this slump test suggest that the use of demolished concrete can increase the workability of fresh concrete.



Graph 4.3 Effect of Demolished Concrete on Slump Value

4.3.2 Compressive Strength Test Results

We conducted compressive strength testing on 36 samples of prepared concrete, each containing different percentages of demolished concrete. We find compressive strength after 7, 14, and 28 days. The purpose of this investigation was to assess the influence of demolished concrete on the compressive strength of the resulting mixture. Four different percentages were examined, 0%, 25%, 50%, and 100% demolished concrete content. The results for all the samples are as follows.

Table 4.8 Compressive Strength of Concrete Samples

Samples with D.C (%)	Compressive Strength (psi) 7 Days	Average Compressive Strength (Psi) 7 Days	Compressive Strength (psi) 14 Days	Average Compressive Strength (Psi) 14 Days	Compressive Strength (psi) 28 Days	Average Compressive Strength (Psi) 28 Days
0	1829.179	1822.52	2532.710	2523.48	2814.122	2803.87
	1822.517		2523.485		2803.872	
	1815.854		2514.260		2793.622	
25	1562.318	1569.634	2163.209	2173.339	2403.565	2414.821
	1569.634		2173.339		2414.821	
	1576.950		2183.470		2426.077	
50	1276.164	1268.211	1766.997	1755.984	1963.330	1951.094
	1268.211		1755.984		1951.094	
	1260.257		1744.972		1938.858	
100	1172.480	1183.057	1623.434	1638.079	1803.816	1820.088
	1183.057		1638.079		1820.088	
	1193.634		1652.724		1836.360	

The comparison between the compressive strength of normal concrete with 0% demolished concrete and modified concrete with 25%, 50% and 100% of demolished concrete are shown below.

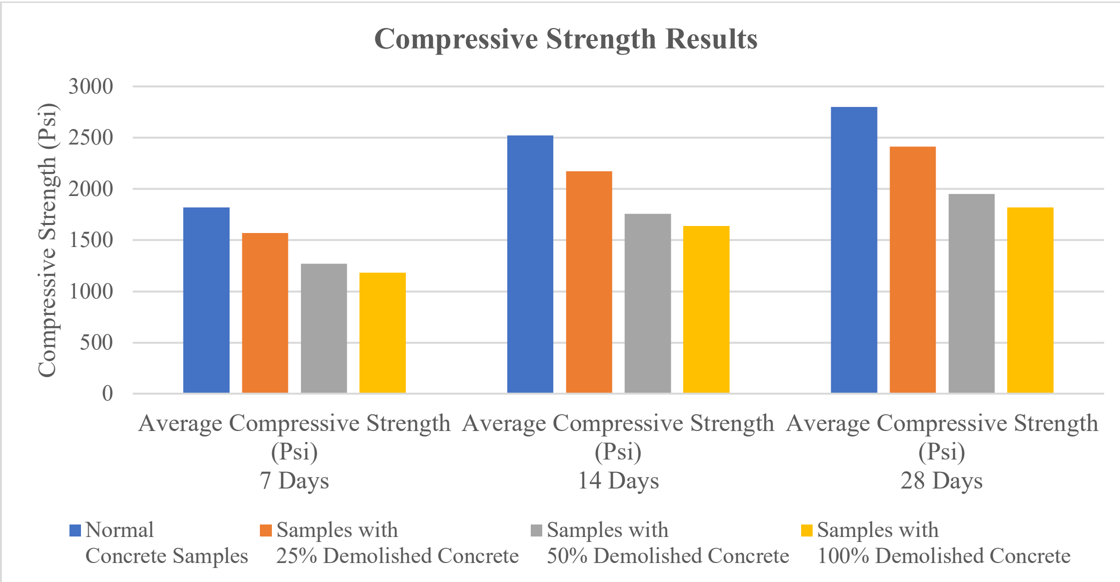
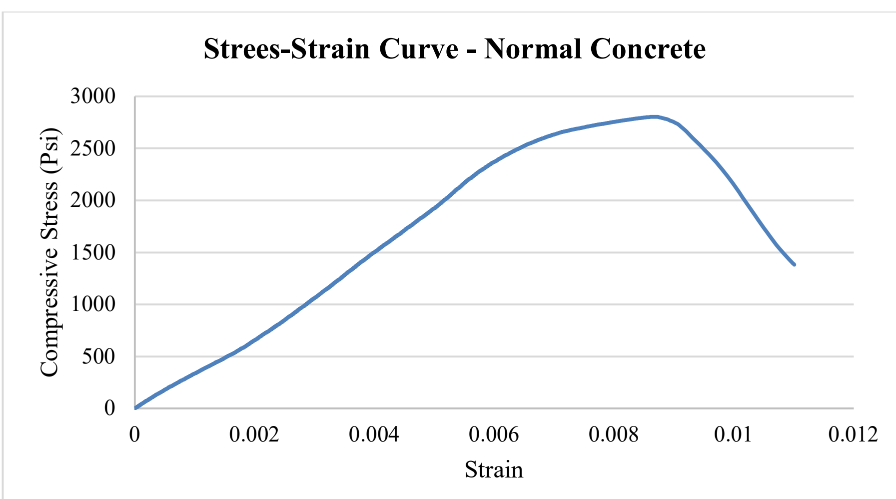


Chart 4.1 Comparison of Compressive Strength

4.3.2.1 Concrete Samples with 0% Demolished Concrete

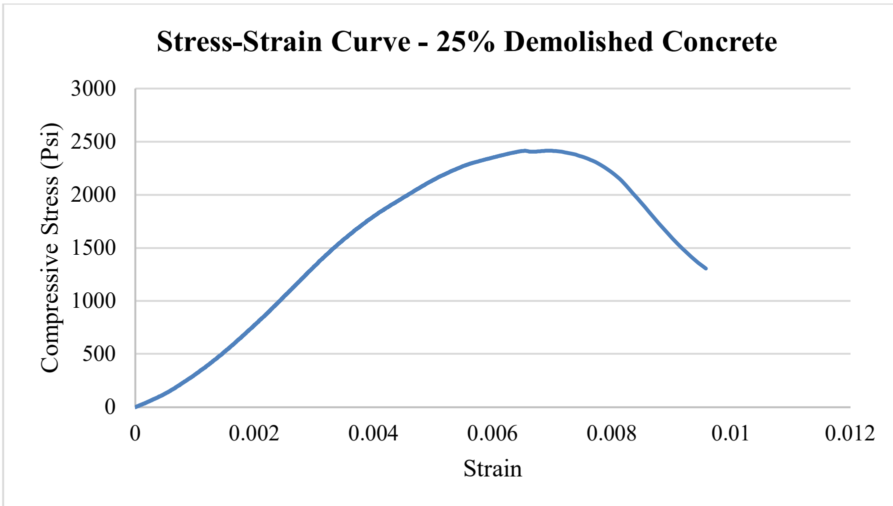
We started from finding compressive strength of normal concrete after 7, 14 and 28 days. The graph shown below represents the compressive stress and the corresponding strain for the normal concrete.



Graph 4.4 Compressive Stress-Strain Curve for Normal Concrete Samples

4.3.2.2 Concrete Samples with 25% Demolished Concrete

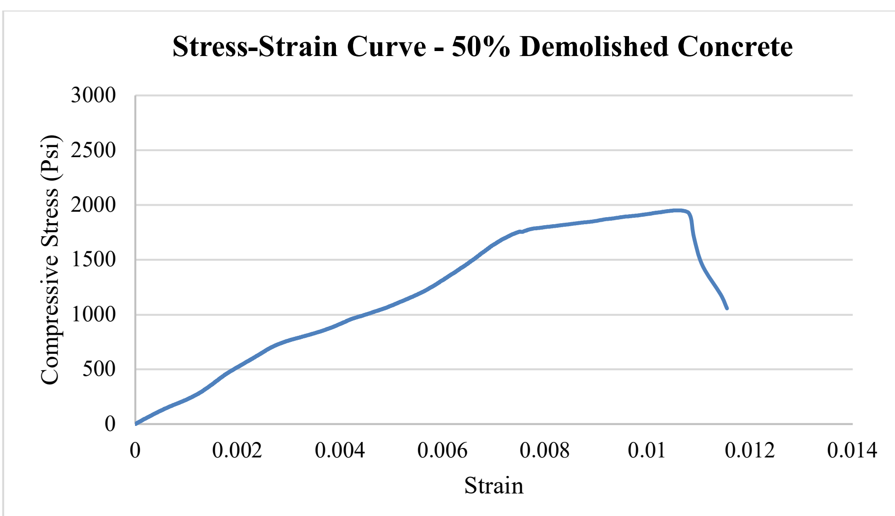
After finding compressive strength of normal concrete, we conducted compressive strength testing on concrete samples that consist of 25% demolished concrete. The graph shown below represents the compressive stress and the corresponding strain for the normal concrete.



Graph 4.5 Compressive Stress-Strain Curve for 25% Demolished Concrete Samples

4.3.2.3 Concrete Samples with 50% Demolished Concrete

After finding compressive strength of concrete samples that contains 25% of demolished concrete as coarse aggregate, we conducted compressive strength testing on concrete samples that consist of 50% demolished concrete

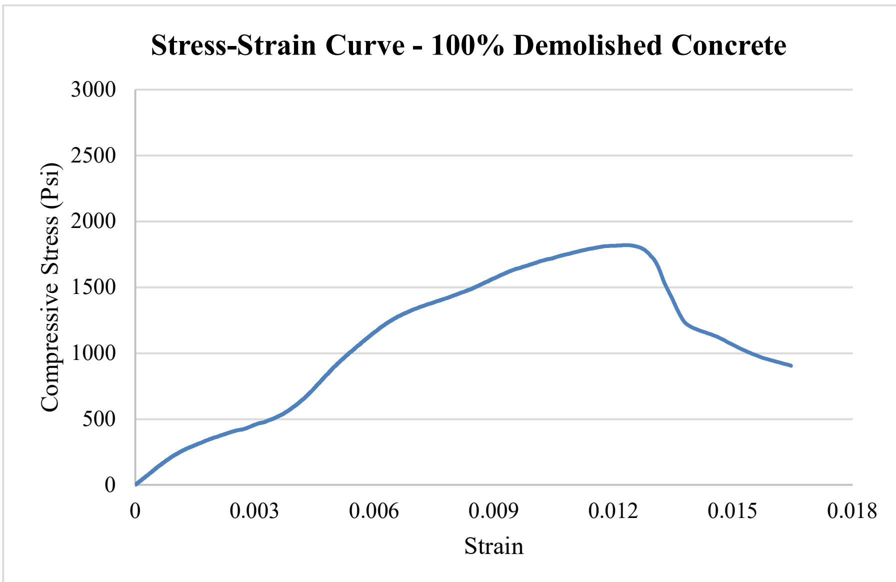


Graph 4.6 Compressive Stress-Strain Curve for 50% Demolished Concrete Samples

The above shown graph represents the compressive stress and the corresponding strain for the normal concrete.

4.3.2.4 Concrete Samples with 100% Demolished Concrete

After finding compressive strength of concrete samples that contains 50% of demolished concrete as coarse aggregate, we conducted compressive strength testing on concrete samples in which we completely replace coarse aggregate by demolished concrete means concrete samples that contains 100% of demolished concrete as a coarse aggregate.



Graph 4.7 Compressive Stress-Strain Curve for 100% Demolished Concrete Samples

The graph represents the compressive stress and the corresponding strain for the normal concrete.

4.3.3 Flexure Strength Test Results

To examine how the inclusion of demolished concrete impacts the flexural strength of concrete beams we conducted flexural strength tests on 36 concrete beam samples. These samples were prepared with the varying percentages (0%, 25%, 50%, and 100%) of demolished concrete used as a coarse aggregate and we tested all the concrete samples after curing it for 7, 14 and days.

The overall results obtained from flexure strength test on all normal and modified concrete samples are as follows

Table 4.9 Flexural Strength of Concrete Samples

Samples with Demolished Concrete (%)	Flexural Strength (psi) 7 Days	Average Flexural Strength (Psi) 7 Days	Flexural Strength (psi) 14 Days	Average Flexural Strength (Psi) 14 Days	Flexural Strength (psi) 28 Days	Average Flexural Strength (Psi) 28 Days
0	302.704	297.99	419.128	412.60	465.698	458.45
	297.991		412.603		458.448	
	293.279		406.078		451.198	
25	263.724	269.090	365.156	372.586	405.729	413.985
	269.090		372.586		413.985	
	274.457		380.017		422.241	
50	237.485	233.432	328.826	323.213	365.362	359.126
	233.432		323.213		359.126	
	229.378		317.601		352.890	
100	216.835	222.862	300.233	308.578	333.593	342.865
	222.862		308.578		342.865	
	228.889		316.923		352.137	

The data shows that the flexural strength of concrete decreases as the percentage of demolished concrete increases. The average flexural strength of concrete samples with 0% of demolished is 292.26 psi, while the average flexural strength of concrete with 100% demolished concrete is 243.58 psi. This is because the crushed recycled concrete is typically less strong than the natural aggregates.

The comparison between the flexural strength of normal concrete with 0% demolished concrete and modified concrete with 25%, 50% and 100% of demolished concrete are shown below

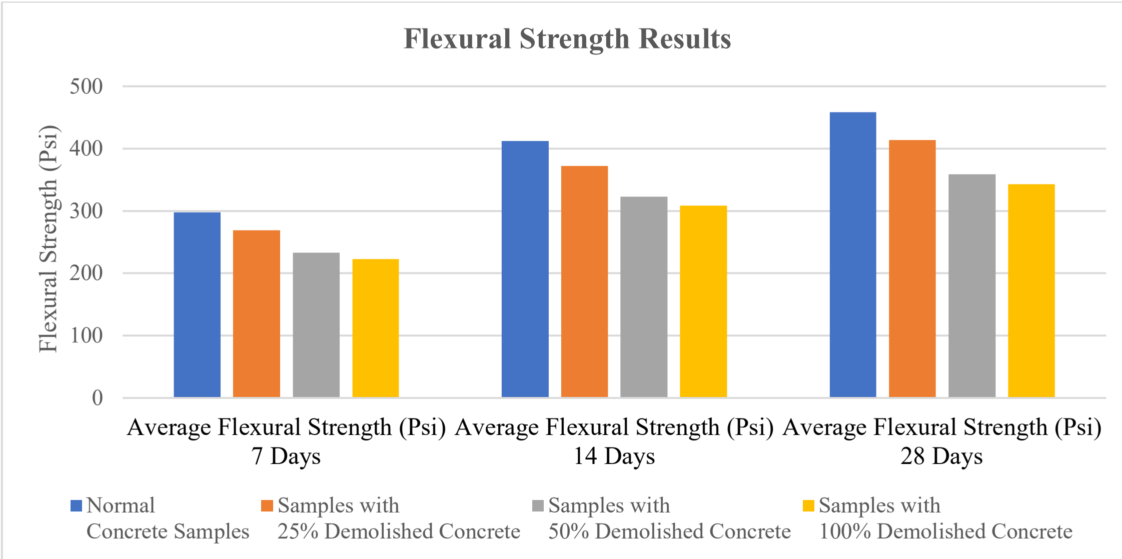
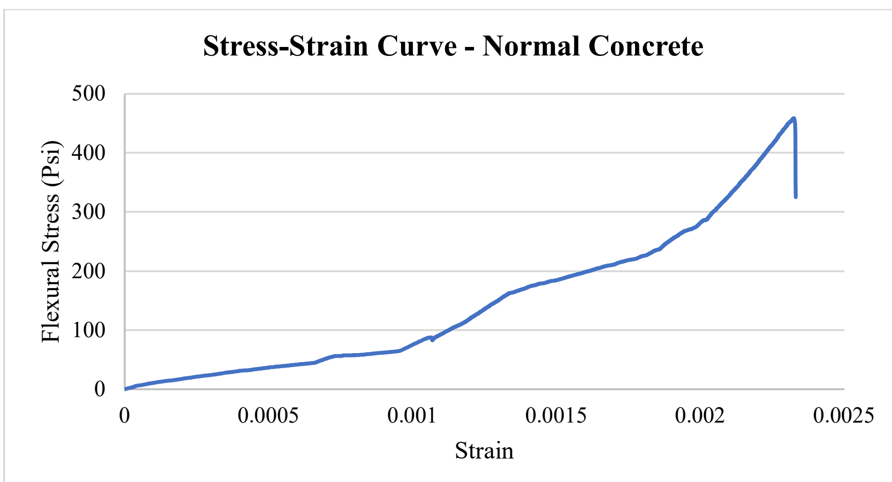


Chart 4.2 Comparison of Flexural Strength

4.3.3.1 Concrete Samples with 0% Demolished Concrete

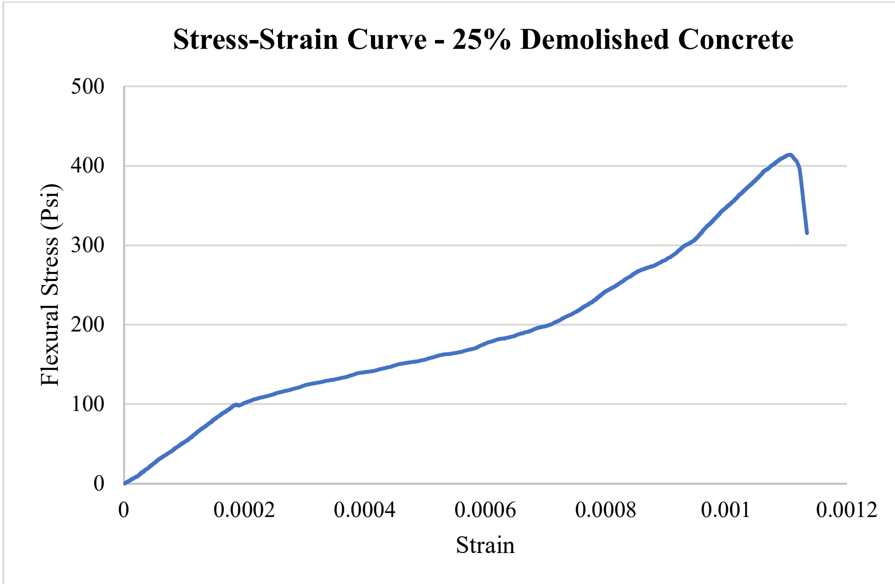
We started from finding flexural strength of normal concrete beam samples after 7, 14 and 28 days. The graph shown below represents the flexural stress and the corresponding strain for the normal concrete.



Graph 4.8 Flexural Stress-Strain Curve for Normal Concrete Samples

4.3.3.2 Concrete Samples with 25% Demolished Concrete

Following the Flexural strength tests conducted on concrete beam samples without any demolished concrete content, we proceeded to perform additional tests on concrete beam samples replacing 25% demolished concrete as coarse aggregates.

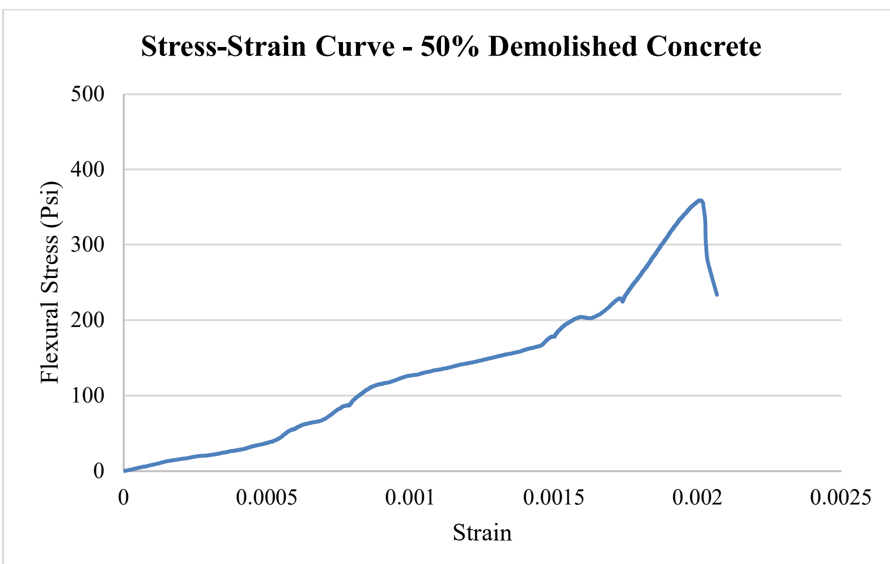


Graph 4.9 Flexural Stress-Strain Curve for 25% Demolished Concrete Samples

The graph represents the flexural stress and the corresponding strain for the normal concrete

4.3.3.3 Concrete Samples with 50% Demolished Concrete

After completing the Flexural strength tests on concrete beam samples that included 25% of demolished concrete as coarse aggregates, we continued with further tests on concrete beam samples where 50% of the demolished concrete was used as coarse aggregates.

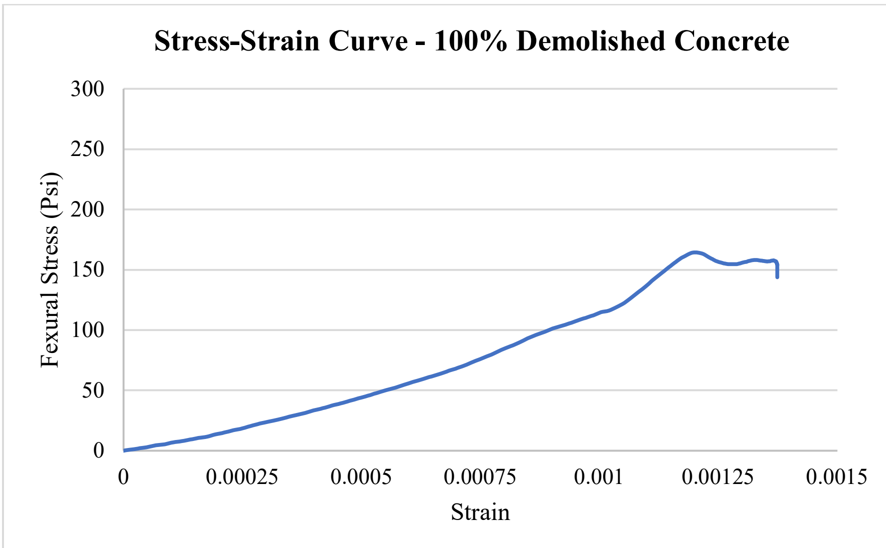


Graph 4.10 Flexural Stress-Strain Curve for 50% Demolished Concrete Samples

The graph represents the flexural stress and the corresponding strain for the normal concrete

4.3.3.4 Concrete Samples with 100% Demolished Concrete

Following the flexural strength tests conducted on concrete beam samples that contained 50% demolished concrete as coarse aggregates, we proceeded to perform flexural strength test on concrete beam samples where 100% of the coarse aggregates were replaced with demolished concrete.



Graph 4.11 Flexural Stress-Strain Curve for 100% Demolished Concrete Samples

The graph represents the flexural stress and the corresponding strain for Concrete Samples that contain 100% of demolished concrete as a coarse aggregate.

4.3.4 Split Tensile Strength Test Results

We conducted split tensile strength tests on 36 concrete samples that were prepared with varying percentages of demolished concrete as a coarse aggregate. We determined that how the inclusion of demolished concrete affects the split tensile strength of the concrete mixtures. We tested four different percentages of demolished concrete content, which were 0%, 25%, 50%, and 100%. After preparing the samples, we cured them for 7, 14, and 28 days before conducting the split tensile strength tests.

The overall results obtained from split tensile strength test on all normal and modified concrete samples are as follows

Table 4.10 Split Tensile Strength of Concrete Samples

Samples with Demolished Concrete (%)	Split Tensile Strength (psi) 7 Days	Average Split Tensile Strength (Psi) 7 Days	Split Tensile Strength (psi) 14 Days	Average Split Tensile Strength (Psi) 14 Days	Split Tensile Strength (psi) 28 Days	Average Split Tensile Strength (Psi) 28 Days
0	537.824	533.04	744.679	738.06	827.421	820.06
	533.042		738.058		820.065	
	528.261		731.438		812.709	
25	236.824	233.358	327.910	323.110	364.345	359.012
	233.358		323.110		359.012	
	229.891		318.311		353.679	
50	438.210	442.663	606.752	612.918	674.169	681.020
	447.116		619.084		687.871	
	442.663		612.918		681.020	
100	195.278	195.278	270.385	270.385	300.428	300.428
	200.059		277.005		307.784	
	190.497		263.765		293.073	

The data from the split tensile strength tests on concrete samples with different percentages of demolished concrete content reveals that normal concrete (0% demolished concrete) consistently exhibits the highest split tensile strength at all curing periods while using 50% demolished concrete can result in a higher split tensile strength compared to samples with 25% and 100% of demolished concrete.

The comparison between the split tensile strength of normal concrete with 0% demolished concrete and modified concrete with 25%, 50% and 100% of demolished concrete are shown below.

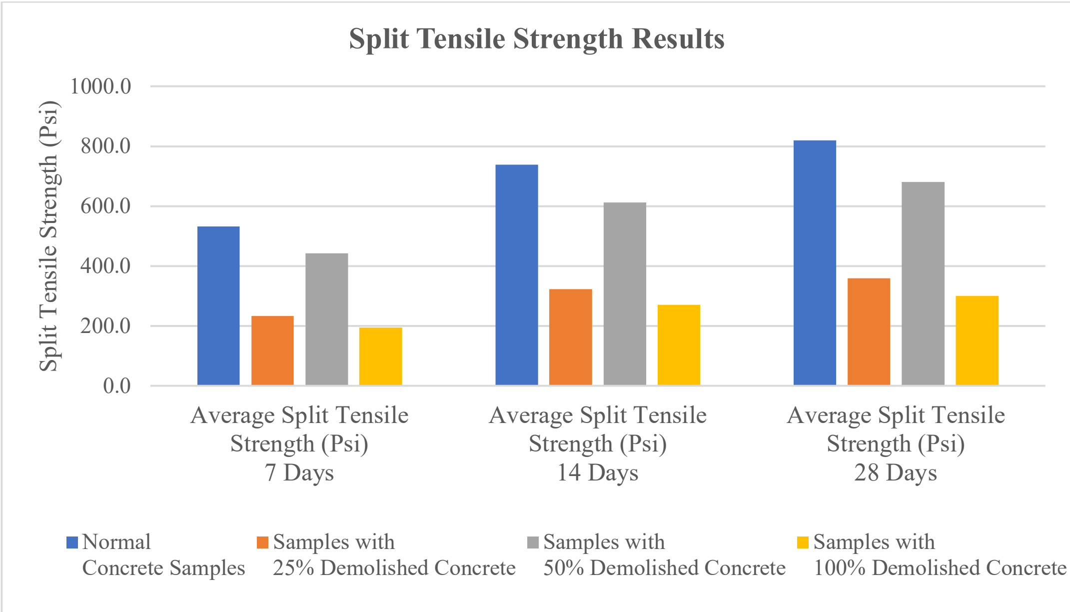
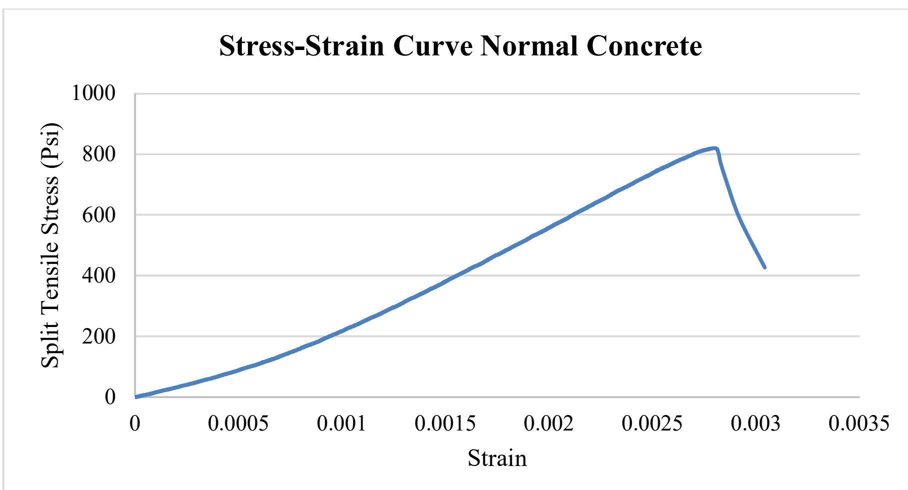


Chart 4.3 Comparison of Split Tensile Strength

4.3.4.1 Concrete Samples with 0% Demolished Concrete

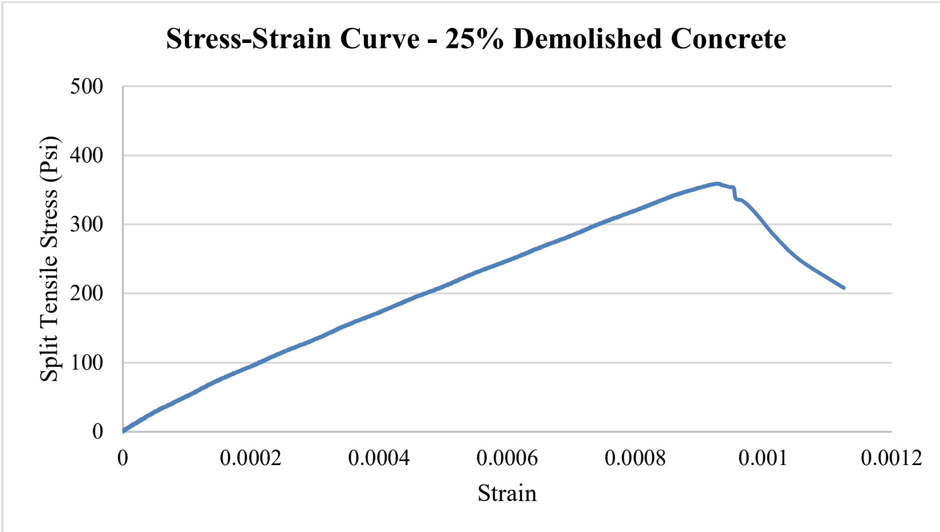
We begin by finding split tensile strength of normal concrete beam samples after 7, 14 and 28 days. The graph shown below represents the slit tensile stress and the corresponding strain for the normal concrete.



Graph 4.12 Split Tensile Stress-Strain Curve for Normal Concrete

4.3.4.2 Concrete Samples with 25% Demolished Concrete

After finding split tensile strength of normal concrete, we conducted split tensile strength testing on concrete samples that consist of 25% demolished concrete.

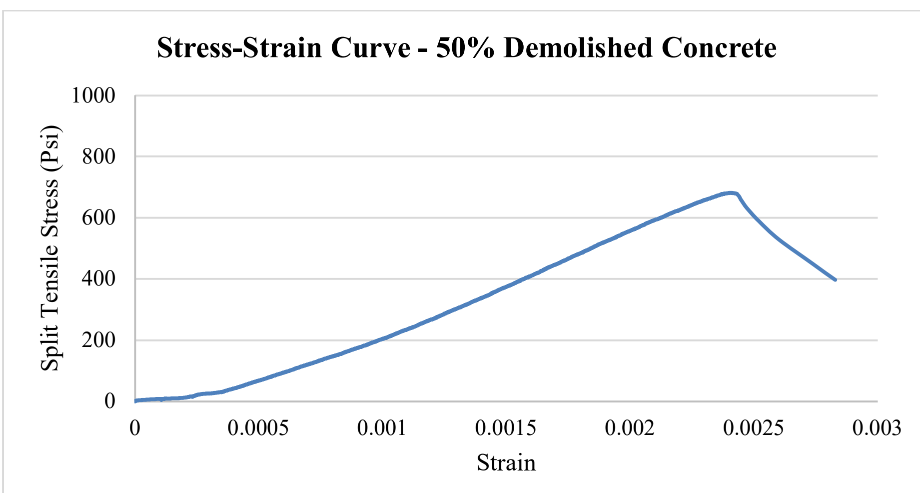


Graph 4.13 Split Tensile Stress-Strain Curve for 25% Demolished Concrete Samples

The graph represents the split tensile stress and the corresponding strain for the concrete samples that contain 25% of demolished concrete as coarse aggregates.

4.3.4.3 Concrete Samples with 50% Demolished Concrete

After finding split tensile strength of concrete samples that contains 25% of demolished concrete as coarse aggregate, we performed split tensile strength testing on concrete samples that consist of 50% demolished concrete.

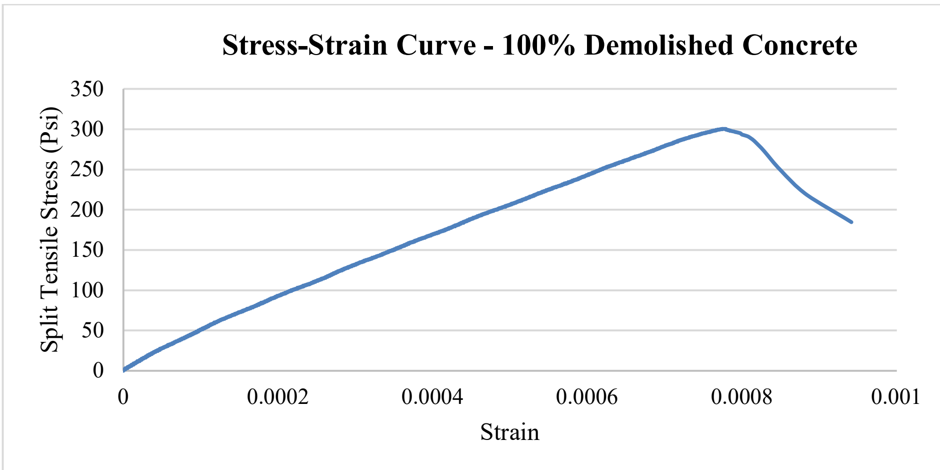


Graph 4.14 Split Tensile Stress-Strain Curve for 50% Demolished Concrete Samples

The graph represents the split tensile stress and the corresponding strain for the concrete samples that contain 50% of demolished concrete as coarse aggregates.

4.3.4.4 Concrete Samples with 100% Demolished Concrete

After finding split tensile strength of concrete samples that contains 50% of demolished concrete as coarse aggregate, we conducted split tensile strength testing on three concrete samples in which we completely replace coarse aggregate by demolished concrete means concrete samples that contains 100% of demolished concrete as a coarse aggregate.



Graph 4.15 Split Tensile Stress-Strain Curve for 100% Demolished Concrete Samples

The graph represents the split tensile stress and the corresponding strain for the concrete samples that contain 100% of demolished concrete as coarse aggregates.

4.4 Cost Analysis

Cost analysis means finding out how much money it costs to use a material. This helps us to find how much money we can save by using demolished concrete which is a waste material as a replacement for coarse aggregates. The cost of concrete can be reduced by using demolished concrete (DC) as a substitute for natural aggregates. The cost analysis shows that the total cost of 1m^{3}normal concrete without using demolished concrete as a coarse aggregate is 16247.3, the total cost of 1m^3 concrete with 25% demolished concrete is 15671.9 PKR, the total cost of 1m^{3}concrete with 50% demolished concrete is 14666.5 PKR, and the total cost of 1m^3 concrete with 100% demolished concrete is 12655.7 PKR. The analysis showed that we can save up to 5 % by using 25% of demolished concrete as a coarse aggregate, up to 10 % by using 50% of demolished concrete as a coarse aggregate and up to up to 25 % by using 100% of demolished concrete as a coarse aggregate. The rate of all the material used and the performed analysis are shown below in table.

Table 4.11 Cost Analysis Data

Description	Quantity	Unit	Rate (PKR)	Amount (PKR)
Normal Concrete				
Cement	6.3	Bag	1100	6930
Sand	0.43	m^3	2190	941.7
Coarse Aggregate	0.88	m^3	4870	4285.6
Labor Cost	1	m^2	4090	4090
Total Volume of Concrete	$1m^3$			
Total Cost of Normal Concrete (PKR)	16247.3			
Concrete with 25% Demolished Concrete				
Cement	6.3	Bag	1100	6930
Sand	0.43	m^3	2190	941.7
Coarse Aggregate	0.66	m^3	4870	3214.2
Demolished Concrete Cost	0.22	m^3	300	66
Labor Cost	1	m^2	4520	4520
Total Volume of Concrete	$1m^3$			
Total Cost of Modified Concrete (PKR)	15671.9			
Concrete with 50% Demolished Concrete				
Cement	6.3	Bag	1100	6930
Sand	0.43	m^3	2190	941.7
Coarse Aggregate	0.44	m^3	4870	2142.8
Demolished Concrete Cost	0.44	m^3	300	132
Labor Cost	1	m^2	4520	4520
Total Volume of Concrete	$1m^3$			
Total Cost of Modified Concrete (PKR)	14666.5			
Concrete with 100% Demolished Concrete				
Cement	6.3	Bag	1100	6930
Sand	0.43	m^3	2190	941.7

Demolished Concrete Cost	0.88	m^3	300	264
Labor Cost	1	m^2	4520	4520
Total Volume of Concrete	$1m^3$			
Total Cost of Modified Concrete (PKR)	12655.7			

Chapter 5
Conclusion and Recommendation

5.1 Conclusion

- Utilizing demolished concrete as a replacement for coarse aggregate reduces the amount of waste sent to landfills, promoting sustainable waste management practices. It helps minimize the environmental impact associated with concrete waste disposal.
- By incorporating demolished concrete into new concrete mixtures, the demand for natural coarse aggregates (such as gravel or crushed stone) is reduced. This helps conserve natural resources and preserves quarries or mining sites.
- Using demolished concrete as a substitute for coarse aggregate can lead to significant cost savings in terms of aggregate procurement. Instead of purchasing new aggregates, the existing demolished concrete can be recycled and utilized, reducing material expenses.
- Reusing demolished concrete as a construction material reduces the amount of waste generated, contributing to waste reduction goals. It helps mitigate the strain on waste management systems and reduces the need for additional disposal sites.
- The presence of demolished concrete in the concrete mixture can enhance the workability of fresh concrete. It can improve the pourability, pumpability, and overall ease of placing the concrete during construction.
- Demolished concrete as coarse aggregate decreased the mechanical properties of the resulting concrete. Compressive strength, flexural strength, and split tensile strength tend to decrease as the percentage of demolished concrete increases.
- The compressive strength of concrete tends to decrease as the percentage of demolished concrete increases. To maintain adequate compressive strength, it is recommended to limit the replacement of coarse aggregate with demolished concrete to around 25% or less.
- Like compressive strength, the flexural strength of concrete is affected by the percentage of demolished concrete. To ensure acceptable flexural strength, it is advisable to limit the replacement to around 25% or less.

- The split tensile strength of concrete is also influenced by the amount of demolished concrete used as coarse aggregate. To maintain satisfactory split tensile strength, it is recommended to limit the replacement to around 25% or less.
- Depending on the application and structural requirements, the reduced strength and potential variability in properties of concrete containing demolished concrete may limit its suitability for certain load-bearing or high-stress applications.
- The use of demolished concrete in concrete mixtures may raise concerns regarding long-term durability. It is crucial to consider factors such as the presence of contaminants, potential degradation of the demolished concrete over time, and the impact on the durability properties of the resulting concrete.

5.2 Recommendations

- Further investigation is recommended to determine the optimum replacement percentage for specific applications. Conducting additional tests on replacing less than 25% of coarse aggregate as demolished concrete.
- Further research should include assessing the resistance of the concrete to environmental factors such as freeze-thaw cycles, chemical exposure, and aging effects. Conducting durability tests will ensure that the concrete meets the required performance standards and remains durable over its service life.
- It is recommended to optimize the mix design by adjusting the water-to-cement ratio and incorporating suitable chemical admixtures which can help in improve workability without compromising the mechanical properties. Trials with different mix proportions and admixtures should be conducted to understand suitable replacement of demolished concrete as a coarse aggregate for the desired workability.

5.3 Sustainable Development Goals

- **SDG#12**, Target No 12.2 (Efficient use of natural resources): Depletion of natural resources can be reduced by utilization of demolition waste.

- **SDG#12**, Target No 12.4 (Responsible management of chemicals and waste): Utilization of construction waste will reduce the amount of waste disposal to the dumping sites.

- **SDG#13**, Target No 13.1 (Climate change): The climate changes will sufficiently reduce due to less mining at the quarry sites.

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