LIGHTWEIGHT CONCRETE USING CONSTRUCTION DEMOLITION WASTE AND INDUSTRIAL WASTE

A

Project Report

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

in

CIVIL ENGINEERING

Under the supervision

of

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

MAY- 2019

STUDENT'S DECLARATION

We hereby declare that the work presented in the Project report entitled **"Lightweight Concrete using Construction Demolition Waste and Industrial Waste"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of our work carried out under the supervision of **Dr. Ashok Kumar Gupta**. This work has not been submitted elsewhere for the reward of any other degree/diploma. We are fully responsible for the contents of our project report.

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Date ……

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"Lightweight Concrete Using Construction Demolition Waste And Industrial Waste"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Sudhanshu Manikpuri (151629), Aayush Jain (151630)** during a period from July 2018 to June 2019 under the supervision of **Dr. Ashok Kumar Gupta (Head of Department)**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: ………………

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ACKNOWLEDGEMENT

The success of any project depends largely on the encouragement and guidelines of many personalities. We take this opportunity to express our gratitude to the people who have been instrumental in the successful completion of this project. We would like to show our greatest appreciation to Dr. Ashok Kumar Gupta for their direction and consistent supervision in the completion of the project. We would also like to thank Dr. Pankaj Kumar, Dr. Saurabh Rawat, Dr. Saurav, Mr. Abhilash Shukla for their guidance and constant support throughout the project. We would also like to thank our lab assistant Mr. Itesh Singh for his cooperation and help throughout the laboratory work. Finally, we would like to thank our friends and individual from Jaypee University of Information Technology for their benevolent support which helped us in fulfillment of this project. We would also like to thank the diverse staff individuals, who have helped us and energized our undertaking.

ABSTRACT

One of the most vastly used material for construction in this world is concrete. At present, population growth is at its peak which is resulting in the remarkable increase in the demand for various construction mechanisms like domestic buildings, bridges, dams, roads etc. Due to this it is getting very difficult to manage the resources required for the construction process. Hence researchers are finding out various ways to deal with the shortage of resources by discovering alternative sources in order to meet the requirements of the present. The key motive of this project work is to analyze the strength of concrete incorporating the recycled aggregate and industrial waste. The objective of this research is to discover up to what proportion the natural coarse aggregate can be substituted by recycled coarse aggregate and industrial waste (plastic waste) in the concrete mix. Also, the objective of this project is to check whether it is feasible to reduce the weight of the concrete block by using the above materials. This project work is focused mainly on the usage of recycled coarse aggregate and plastic waste. A number of tests were carried out to determine the compressive strength with and without recycled aggregates. Natural coarse aggregates in concrete were substituted with various proportions of crushed concrete coarse aggregates and plastic waste.

Keywords: Natural coarse aggregate, Recycled coarse aggregate, Plastic waste Compressive strength

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LIST OF ACRONYMS & ABBREVIATIONS

CDW	Construction Demolition Waste
NCA	Natural Coarse Aggregates
NFA	Natural Fine Aggregates
PW	Plastic Waste
PPC	Pozzolana Portland Cement
RCA	Recycled Coarse Aggregate
RAC	Recycled Aggregate Concrete

CHAPTER 1
INTRODUCTION

1.1. General

Development advancements are on its top in the 21st century around the world in the field of construction. There are various bridges, deep-water structures, roads, sky-scrapers, and underground tunnels everywhere throughout the world. To suit new structures, numerous structures worked in the previous hundreds of years are being demolished and crushed because of their breaking point of life expectancy, unacceptable position in a regularly developing city, and harmed condition brought about by natural events. The devastation of structures is creating concrete rubbles and triggering ecological issues because of impromptu disposal and shortage of landfill sites. An extensive segment of the possibly helpful devastation waste is arranged off in landfill sites. The vehicle and discarding of this waste are financially and ecologically not economical. Since concrete is the most broadly utilized construction material on the planet today, this thesis centers around a particular segment that represents 80% of the volume of concrete, i.e. aggregates. Aggregates are ending up progressively rare in metropolitan areas. That implies that aggregates must be transported from longer separations into the urban regions, which is the place most buildings are built. To reduce these issues, the idea of alternative aggregates is attracting more intrigue the construction business. One of the approaches to take care of this issue is to utilize this 'waste' concrete as aggregates. Such 'recycled' aggregate could likewise be a solid alternative to utilizing natural aggregates in concrete construction.

Reutilizing demolition waste was initially carried out after the Second World War in Germany. Ever since then, numerous research work is carried out in different countries which provided proper evidence that construction waste can be incorporated in production of new concrete. Construction and Demolition (C&D) waste include damaged concrete, broken pavement, or bricks from buildings. In this way, Recycled Aggregate (RA) could be extracted from the destruction of buildings, concrete roadbeds, airport runways, and bridge supports. Concrete made up of such aggregates is known as Recycled Aggregate Concrete (RAC).

1.2. Aggregates

The solid principle constituent in concrete that is inert in nature and is made up of granular materials like sand, crushed rock, gravel and clinker is known as aggregate. Apart from being an alternative to produce concrete more economically feasible, aggregates play a significant job in the concrete as cement on its own is incapable to satisfy the requirement of construction responsibilities. Along these lines, it is very well explained that aggregates are the most essential element of concrete and it is very difficult to create buildings and infrastructures without this important element.

The extraction is carried out on a broad range of naturally occurring resources from which these aggregates are acquired. The commonly used aggregates like sand and gravel are derived from the base of rivers, lakes and ocean. The bedrocks are broken down by explosions using a detonator which gives us crushed stones that is processed further to obtain coarse aggregate. The volume of concrete comprises of about 70% to 80% of aggregates.

1.2.1. Classification of Aggregates according to size

1.2.1.1. Fine Aggregate

The aggregates passing through 4.75 mm sieve are termed as fine aggregates. Generally, sand extracted from rivers are utilized as fine aggregate. Similarly, Silt and clay also fall under this category. The delicate deposit comprising silt, sand, and clay is defined as loam. The objective of fine aggregates is to fill the voids that are present between the coarse aggregates. The small particle size helps the fine aggregate to enter the voids resulting in higher strength of concrete.

1.2.1.2. Coarse Aggregate

The aggregates retained on 4.75 mm sieve are termed as coarse aggregates. They are the strength building component of concrete. The strength of the concrete is highly dependent on the quality of coarse aggregates. This category of coarse aggregate consists of gravel, cobble and boulders. Usually, high strength concrete is made up of 20mm size aggregate whereas 40mm size aggregate is used for normal strength concrete. Fig 1.1 shows natural coarse aggregates.

Fig 1.1 Coarse aggregate

1.3. Recycled Aggregate Concrete

Talking about the world, concrete has been the most important and broadly used construction material. With the passage of time there has been a lot of development in the construction industry. Due to the rapid urbanization, the demand for new buildings and structures is increasing day by day which in turn is increasing the level of pollution. In order to minimise this problem we have to develop new methods and products which are sustainable and provide an eco-friendly solution. Using waste materials in the form of RA in concrete is a very good solution for this problem. Researches that were carried out to find the materials that can be used for the production of RA demonstrated that waste concrete which consist coarse and fine debris from demolition sites is a suitable option. The concrete which consist RA as a component is known as recycled aggregate concrete. RAC can be considered as a vital option as an eco-friendly element as well as it is an effective cost saving material. Recycled aggregate concrete cubes are shown in Fig 1.2.

Fig 1.2 Recycled aggregate concrete cubes

1.3.1. Recycled Aggregate Manufacturing

Three major steps are involved in the manufacturing of Recycled Aggregate Concrete (RAC):

1.3.1.1.Source Concrete Evaluation

The quality of concrete needs to be determined for the production of RAC. Properties and records of source concrete like strength, composition, and durability are observed for determining the proper source concrete.

1.3.1.2.Crushing of destroyed concrete

The basic procedure includes crushing concrete into determined size and quality (size usually between 20 mm – 50 mm).

1.3.1.3.Contaminants Removal

Materials like asphalt concrete shoulders, reinforcing steel, soil, foundation materials, etc. which are considered as contaminants are removed. It can be done by various methods comprising demolition, screening or air separation, using electromagnets, etc. Depending upon the use of RCA some other contaminants need to be processed separately.

1.3.1.4.Advantages of recycled aggregate concrete

It lessens the quantity of virgin aggregates to be generated resulting in less extraction of natural resources. RAC is very economical as it is extracted from waste and in this way it helps to reduce the construction cost. It is cost saving as it reduces the requirement of new landfills by conserving the landfill space. It creates a lot of opportunities for employment in the construction industry.

1.3.1.5.Disadvantages of recycled aggregate concrete

The quality of concrete gets deteriorated. The rate of absorption of water utilizing RAC as a concrete element is increased by 3% to 9%. The workability of concrete is reduced.

1.3.1.6.Applications of recycled aggregate concrete

The construction of pavements, gutters, etc. are suitable application of RAC. In order to control soil erosion, revetments are built which help to hold the soil together. These revetments are made up of large pieces of crushed aggregates. The concrete rubbles which undergo the recycling process can be induced as coarse aggregates in the production of new concrete. A lot of by-products are generated during the process of concrete production using RAC as an element which can be utilised as a concrete addition, asphalt fibre, ground improvement material etc.

1.4. Plastic Waste

The construction industry is now dealing with a new kind of waste i.e. plastic waste. Recycled plastic can be used as a construction material in order to bring it back into the production line. Recycled plastic provides various advantages like its lighter weight, durability, resistance to impact, chemicals, and water. It also exhibits great insulation for electrical and thermal properties.

On the other hand, it has some disadvantages also like low bonding properties which reduces the compressive strength of concrete. Our objective to use plastic waste in this project is to check whether substitution of coarse aggregates with plastic waste is possible or not. And if possible, then up to what extent coarse aggregates can be replaced by plastic waste to achieve a concrete with a good compressive strength that can used in the real world. Fig 1.3 shows plastic waste.

Fig 1.3 Plastic waste

1.5. Recycling of Plastic

The process of recovering plastic from the waste materials and then incorporating it into the manufacturing process is known as recycling of plastic. Recycling plastic is one of the prominent method used in the present with virtue of the future.

The three main aspects of recycling process are that the valuable natural resources which are in limited quantity are preserved; the cost of transportation and costs associated with it are minimised; the problems of space requirements are dealt as the waste materials are causing a significant impact on the environment.

1.5.1. Benefits of concrete incorporating plastics

There are a lot of benefits in using recycled plastic because of its vast properties like it exhibits tremendous versatility and can be personalised according to the required technical needs. The transportation cost is reduced as the plastic is lighter in weight as compared to other materials. The plastics is highly durable and it also exhibits longevity. It displays high resistance to water, impact and chemicals. It provides better insulation against thermal and electrical properties. The cost of production is very less as compared to other materials. At melting point, the temperature and bonding capacity are directly proportional to each other.

1.5.2. Drawbacks of utilizing plastics in concrete

The compressive, flexural and tensile strength shows a decrement if using plastic as a substitute because of its low bonding properties. The plastic is highly affected by temperature. This is because of the low melting point of plastic. The plastic starts to melt at high temperatures because of the heat produced.

1.6. Silica Fume

The byproduct obtained during the production of silicon metal or ferrosilicon alloys is known as Silica Fume. It provides an extraordinary benefit when utilized in concrete, i.e. strength. It is a very reactive pozzolan because of its significant physical and chemical properties. Due to these properties, silica fume enhances the strength of the concrete to a great extent. Also it helps to improve the durability of the concrete produced.

The primary component of silica fume is amorphous(non-crystalline) silicon dioxide(SiO_2). The special thing about this material is that the size of silica fume is so small that when compared to an average cement particle, its size comes out to be approximately 1/100th the size of the average cement particle. This fineness of particle is responsible for the large surface area of silica fume. This fineness of particle, high SiO_2 content and large surface area makes this material a highly reactive pozzolan when talking about its implication in concrete production.

Generally, the specific gravity of silica fume is determined in the range 2.2-2.3 because of its extremely fine particles. The main objective of using this highly reactive material in concrete production is that it enhances various properties like compressive strength, abrasion resistance, and bond strength. These upgrades originate from both the mechanical enhancements coming about because of expansion of an extremely fine powder to the cement paste mix just as from the pozzolanic reactions between the silica fume and free calcium hydroxide in the paste. Fig 1.4 shows silica fume.

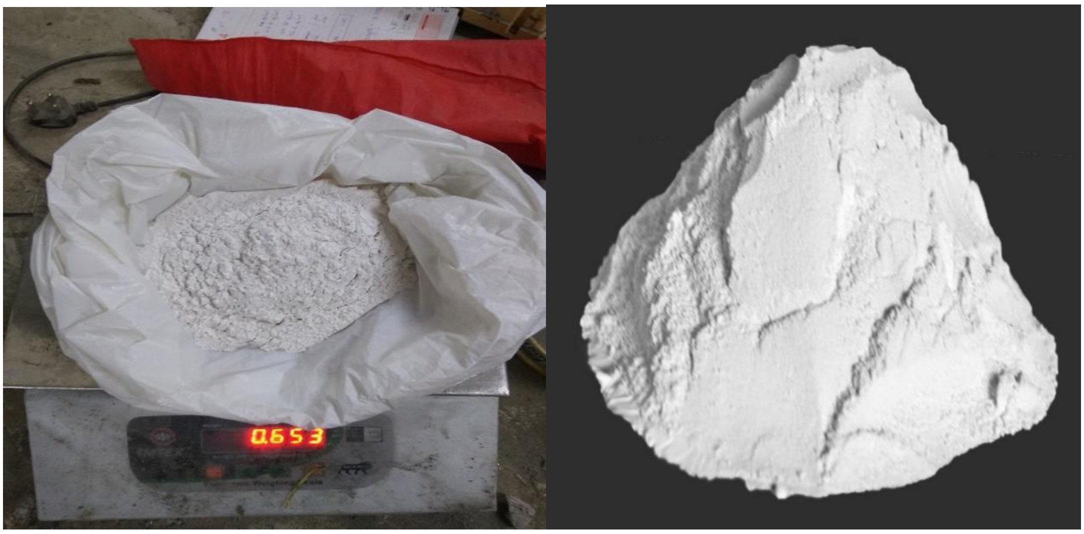

Fig 1.4 Silica fume

1.6.1. Effects of silica fume on various properties of fresh and hardened concrete

Workability**:** With the introduction of silica fume, the slump loss with time is legitimately relative to increment in the silica fume content because of the presentation of large surface area in the concrete mix by its addition. In spite of the fact that the slump diminishes, the mix remains exceptionally cohesive.

Bleeding and Segregation: Silica fume lessens bleeding significantly in light of the fact that the free water is utilised in wetting of the extensive surface area of the silica fume and thus the free water left in the mix for bleeding likewise diminishes. Silica fume likewise obstructs the pores in the new concrete so water inside the concrete isn't permitted to rise to the top of the surface.

1.6.2. Advantages of Silica Fume in concrete

Silica fume is a kind of neutral inorganic filler with very stable physical and chemical properties. It does not contain crystalline water, does not contribute in the curing process, and the reaction mechanism is unaffected by it. Also, it provides better infiltration for various types of resin, good adsorption performance, no agglomeration phenomenon, and easy to mix. The size distribution of silica fume is reasonable, strong densification, large hardness and wear resistance. It can greatly improve the tensile strength, compressive strength, impact strength and wear resistance of the cured products, and the abrasion resistance can be increased 0.5–2.5 times. The flame retardancy and thermal conductivity is increased with the addition of silica fume. Also the adhesive viscosity is altered by it. The exothermic peak temperature of curing reaction of epoxy resin can be reduced. The linear expansion coefficient of solidified products and the shrinkage rate of solidified products can be minimised, so as to eliminate internal stress and prevent cracking.

1.6.3. Disadvantages of Silica Fume in concrete

Silica fume concrete shrinkage rate is large, especially early dry shrinkage, easy to make crack in the application of silica fume concrete, affect the overall strength and using effect. For example, after construction, strengthening water and sprinkler maintenance can decrease this problem, but the cracks are still unavoidable in many construction projects.

The workability of concrete is an important parameter in the design of concrete mix proportion, silica fume concrete workability is poor, is not easy to make the concrete vibrating close grained, not easy to plaster, affecting the quality of concrete regarding smoothness and uniformity of the surface.

Concrete with silica fume early strength develop quickly, the corresponding concrete hydration heat dissipation quickly, resulting to rise concrete hydration heat temperature, easy to produce high temperature stress in the concrete, the stress concentration in the top of the dry shrinkage crack, make dry shrinkage crack extend even through the formation of transfixion cracks.

1.6.4. Applications of Silica Fume

Marine structures, highway bridges, parking decks, and bridge deck overlays are liable to consistent disintegration brought about by rebar corrosion current, abrasion and chemical attack. Silica fume will ensure concrete against seawater, traffic, deicing salts, and heavy impact. Rebar corrosion movement and concrete crumbling are practically wiped out, which limits upkeep cost.

1.7. Compressive Strength

The ability of a structure to resist cracks, or deflection on its surface on application of loads is termed as compressive strength of concrete. When it is said that a material is subjected to compression, it means that the size of the material reduces, while in tension the size increases. The compressive strength of concrete helps us to determine the characteristics of concrete. Compressive strength test directly gives us the idea whether the concreting has been done properly or not. There are a lot of factors like cement strength, water-cement ratio, quality control during production of concrete, quality of concrete material, etc. which are responsible for the compressive strength of concrete.

A cube or cylinder is used for the test of compressive strength. There are standard codes which recommend concrete cubes or cylinder acting as the standard specimen required for the test. Fig 1.5 shows compression testing machine.

Fig 1.5 Compression testing machine

CHAPTER 2
LITERATURE REVIEW

2.1. General

Concrete is broadly utilized in the world today and since aggregates are an essential part of concrete, this thesis focuses mainly on the utilization of RA in the creation of concrete. The product so formed is termed as Recycled Aggregate Concrete (RAC). The motive of this project work is evaluate and study the changes in mechanical behavior of concrete utilizing RA with that of conventional concrete that is made up of naturally occurring aggregates. The mechanical performance of the above two concrete types is compared and the resulting differences are studied. The works of various researchers are discussed below.

2.2. Literature Review

Limbachiya et al. (2004) In this research work, the researchers carried out an experiment in which they replaced the natural aggregates with 100% coarse recycled aggregates. They observed the effect of this replacement on a range of engineering and durability properties. They also checked whether it can be used for future purposes in various applications in the construction industry. They used cubes of concrete of dimension 100 mm for the test of compressive strength. These casted cubes were left for curing for 28 days in water with a temperature of 20°C. The outcomes demonstrated that the use of 30% coarse RCA doesn't affect compressive strength, however from there on a gradual reduction with increasing RCA content takes place.

Song Gu et al. (2009) carried out a research that showed the old mortar particles attached with the aggregates increases the water absorption rate to a great extent as compared to that of natural aggregates. As the replacement rate of RCA increases, the slump and strength decreases. Fly ash can help to enhance the workability of recycled concrete. The strength of concrete does not decrease up to 30% replace of fly ash.

Loo et al. (1988) carried out a research on "Strength evaluation of Recycled aggregate concrete by in-situ tests" in which the compressive strength of concrete was observed at different periods as long as 90 days utilising cubes of dimension 100 mm. the outcomes demonstrated that the compressive strength, for a definite water-cement ratio is less of recycled aggregate concrete as compared to that of concrete utilising natural aggregate. The outcomes likewise displayed that the relation between the water-cement ratio and strength at the two ages pursues a comparative trend for the RAC just as the NAC of the concrete.

Yong et al. (2009) carried out a research on "Utilisation of recycled aggregate as coarse aggregate in concrete". For the experiment, recycled concrete aggregate was used which was derived from specimens that were site-tested. The primary motive of this project work was to utilise recycled aggregate in the concrete production as coarse aggregate. The main emphasis was to determine the possibility of replacement of RCA in concrete. Natura coarse aggregate, natural fine aggregate and RCA were used in this experiment. Replacement of 0%, 50%, and 100% of RCA was done to make the concrete. Also a concrete was produced which consisted of Saturated Surface Dry(SSD) RCA using a similar mix proportion. Concrete with 100% replacement of RCA gave the most critical 7 days and 28 days' compressive strength of 41.25 MPa and 58.95 MPa respectively. The result showed that the concrete with 50% replacement of RCA gave a compressive strength that was very close to that of conventional concrete.

Bhavani et al. (2012) carried out an experiment to observe the performance of recycled aggregate concrete(RAC) as compared to that of concrete consisting naturally occurring aggregates. The mix design that was adopted was M20 and the water-cement ratio was taken as 0.4. The compressive strength of the natural aggregate concrete(NAC) and the concrete so obtained by replacing RAC was examined at 7-days and 28-days. The results show the difference between the compressive strength of RAC and NAC as average 87% in which RAC was lower. Also, another thing that was observed was that the slump formed was low which can be enhanced by using Saturated Surface Dried(SSD) of RCA. In light of the acquired outcomes the researchers proposed that it is feasible to use RCA which is extracted from demolition waste as replacement of aggregates to produce a new concrete. Although the strength of recycled aggregate concrete is less than that of NAC, it can be used for various other purposes that has certain applications in the construction industry.

Lee et al. (2012) carried out an experiment to analyse the compressive strength of concrete consisting coarse RA extracted from old concrete debris. The results established that the compressive strength of concrete has not declined. However, the experiment could not confirm that using coarse concrete debris affects the strength of concrete.

Silva et al. (2014) explains that the best applications for RA are in landscaping, road pavements and mortar/concrete. The material heterogeneity is further increased respect to natural aggregates which can cause larger problems in concrete, but affirms that some positive results have been obtained, considering crushed concrete aggregates as a good example. Generally, when incorporating masonry rubble (such as ceramics or light-weight concrete), mechanical strength is thought to be reduced. Asphalt, gypsum, metals, plastic, rubber, soil or wood are considered as contaminants and can degrade the concrete strength drastically. For this reason, selective demolition is strongly recommended so that this recycled aggregate can be implemented properly in concrete mixes.

Ciria (2009**)** conducted a research regarding the initial considerations for using RCA in concrete. The results exhibited that factors like workability, deformation, and compressive strength were affected with not more than 20% of coarse aggregate replacement. The reduction in quality was evident for higher replacement proportions. Durability was not affected for concrete of equal w/c ratio, and compressive strength, irrespective of the percentage aggregate replaced.

Etxeberria (2004) conducted a research which gives us an idea about the structural behaviour and durability. These two factors are important to account for while using RCA. Structural behaviour depends on the percentage of RCA used, and durability depends on the heterogeneity of recycled particles. That is why chemical, physical, and mechanical properties of original coarse aggregates need to be identified as well as original fine aggregates present in adhered mortar. The results also showed that density and absorption are affected by the quality of the adhered mortar, and porosity is affected by the water-cement ratio of the recycled concrete. The particle size as well as the procedure of crushing of concrete debris also influences the amount of mortar adhered. On the other hand, the workability is affected by the use of RCA in condition of dryness. The shape and texture also affects workability. Reduction of water-cement ratio also help to keep the same compressive strength increasing the amount of replacement of coarse RCA, but not in the case of coarse and fine aggregate replacement, which requires high cement content to sustain the resistance.

Suryawanshi et al. (2015) focused on compressive strength tests carried out on concrete cylinder samples with dimensions- 150mm(dia.) and 200mm(height). Debris of old concrete was crushed manually with the help of a hammer in the laboratory from which the RA was extracted. The results showed a gradual decrease in compressive strength as RA was increased. However, even on replacing 100% RA, the decrease in compressive strength of concrete was found out to be 11%.

Nabajyoti and *Brito* (2012) carried out a research clarifies that even though plastic is effectively combustible, burning it will discharge poisonous chemicals like harmful dioxins into the atmosphere. Another choice is to store it in landfills, is a similarly bleak option since plastic isn't a bio-degradable material and thus, hurtful substances tend to remain in the soil for a very long time. Since the interest for concrete is consistently increasing, a conceivable choice inspected by researchers is to include plastic as RA for concrete production. This has all the earmarks of being a standout amongst the most ideal natural answers for dispose of this undesirable waste.

Ismail and *Al-Hashmi* **(**2008**)** carried out a research to determine the compressive strength of 70 concrete cubes of dimension 150 mm. The plastic used in this experiment was in shredded form which was gathered from plastic manufacturing companies in Iraq. The composition of this material was 80% polyethylene and 20% polystyrene. The results demonstrated that on using 20% of shredded plastic, the compressive strength of concrete so formed declined by 40%. The researchers explained the poor results so obtained because of the low adherence levels between plastic and concrete paste. On the other hand, they also suggested that the least necessity for the compressive strength of concrete is 18,25MPa in Iraq. Hence, plastic waste can possibly be used as RA.

2.3. Summary of the Literature Review

Numerous researches are being carried out to check whether waste materials can be utilised in concrete advancements. The use of RA as a substitution for aggregates in concrete production is feasible when considering the compressive strength of RAC. The rate of absorption of water is high in case of recycled concrete. On the other hand, the specific gravity is low. Therefore, adjustments are required during the process concrete preparation. Concrete consisting RA displays permeability, higher shrinkage, and creeps as compared to conventional concrete. Due to low bonding between concrete paste and plastic/rubber, the compressive strength was not satisfactory Concrete incorporating waste materials cannot be used for load-bearing structures. They are a good option for purposes like public pavements or school playgrounds as requirement of compressive strength for these purposes is not to a great extent.

2.4 Objectives

- To evaluate and study the influence of recycled aggregates as replacements of the natural coarse aggregate on the compressive strength of the concrete
- To study the influence of the use of plastic waste as aggregates on the compressive strength of concrete
- To check whether it is feasible to produce a lightweight concrete using plastic waste and RAC as replacement for the Natural coarse aggregate.
- To estimate up to what extent it is feasible to replace RAC and PW to achieve an acceptable compressive strength.

CHAPTER 3
METHODOLOGY

3.1 General

This phase of the project was carried out in various stages like testing of cement and aggregates to find their properties and then suitably using them to form a concrete mix. This mix is then casted in cubes using moulds.

3.2. Test for cement

3.2.1. Consistency Test

This test helps us to check the consistency of the cement paste. It is characterized as the consistency at which a vicat plunger of measurement 10 mm and length 50 mm can penetrate the mix till depth of 33 to 35 mm from the highest point of the mould. Fig 3.1 shows vicat apparatus.

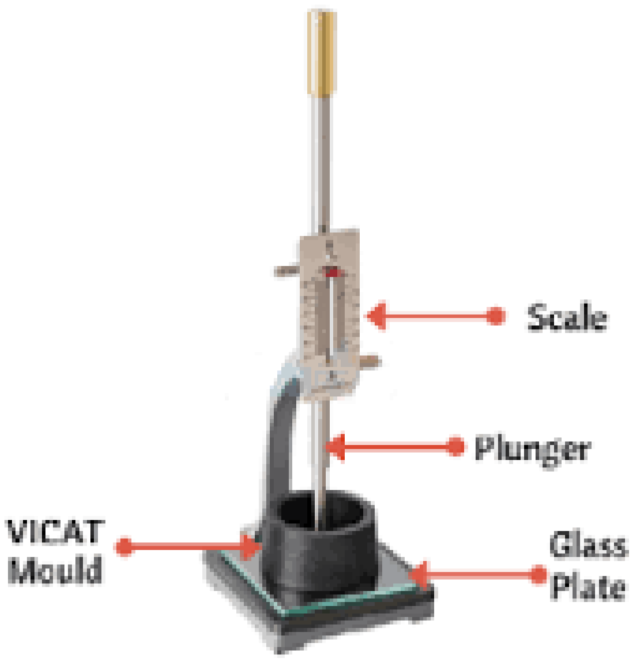

Fig 3.1 Vicat apparatus

3.2.2. Specific Gravity of Cement

It can be defined as the ratio of density of a substance with reference to a standard substance for the same volume, keeping the temperature and pressure constant. Fig 3.2 shows le-chatelier flask

Fig 3.2. Le-Chatelier flask

3.2.3. Initial and Final setting time of cement

A cement paste was prepared by gauging the cement with 0.85 times the water needed for a paste of standard consistency. At the instant when water is added to the cement, a stop watch is started. The Vicat mould is completely filled with the cement paste already prepared before and is placed on a plate which is non-porous in nature. The surface of the paste is made smooth, making it level with the top of the mould. The block of cement so obtained is the test block.

Initial setting time: This arrangement consists of a test block and rod bearing needle. The block was put under the rod bearing the needle. The needle was delicately brought all together down to reach the surface of the cement paste and discharged rapidly, enabling it to penetrate the test block. The methodology was repeated until the needle neglects to penetrate the test block to a point 5.0 ± 0.5mm estimated from the base of the mould. The time elapsed between the time, water was added to the cement and the time, the needle neglects to penetrate the test block by 5.0 ± 0.5mm estimated from the base of the mould, was the initial setting time. Fig 3.3 shows vicat apparatus.

Fig 3.3. Vicat Apparatus

Final setting time: There was a replacement of the above needle with an annular attachment. It was assumed that the cement is finally set when upon releasing the needle on the surface of the test block, there was impression which appeared on the surface while the attachment did not provide the same. The time period elapsed between this time was termed as the final setting time.

3.2.4. Fineness test of cement

It is a property of cement which gives us an idea about the particle size and surface area of cement. It is measured by sieving the cement using a standard sieve. The grain size that are larger than 90-micron sieve are that proportion which are needed to be determined. The fineness depends on the specific surface area. Higher the specific surface, finer the cement is.

3.3. Test of aggregates

3.3.1. Water absorption of aggregates

The amount of water absorbed by the aggregates when submerged in water is known as water absorption of aggregates. It is important to determine this parameter as it is directly linked with the strength of the concrete. Higher the water absorption, lower the strength will be. Fig 3.4 shows wire basket.

Fig 3.4. Wire basket

Apart from this various other tests were conducted on cement, natural coarse aggregates, and natural fine aggregates and their results were obtained.

3.4. Mix design quantity of concrete per cubic meter

The mix proportion of M30 grade of concrete was prepared using zone II gradation sand, 20 mm coarse aggregate with a w/c ratio of 0.42. The mix design ratio used is 1:2.84:1.69 representing cement: coarse aggregate: fine aggregate. This design is described in the table below:

Table 3.1 Concrete mix proportion of M30 grade

Type	**Quantity (kg/m^3)**
Cement	400
Water	167.4
Coarse Aggregate	1135
Fine Aggregate	675

3.5. Concrete cube specimen preparation

Using the mix design, the amount of materials required was calculated. The materials were collected accordingly and then were indulged in the casting process.

Fig 3.5 shows mixing of materials in a tray.

Fig 3.5. Mixing of Materials

3.6. Mixing of Concrete for Cube Test

At first the materials were put in a tray and mixed with trowel in the dry conditions so that there is an even mixing of components. Then this mixture was taken and put in the concrete mixer where the addition of water takes place. The water is added in parts for uniformity of mixture. When the mixture appears to be properly mixed, it is taken out in the tray which is brought to fill the already prepared moulds. Fig. 3.6 represents concrete ingredients. Fig 3.7 shows mixing of materials in concrete mixer.

Fig 3.6. Collection of materials in a tray

Fig 3.7. Concrete mixture in mixer

3.7. Cube sampling

The moulds are tightened with nuts and bolts using a rinch. After that they are properly greased with oil in order to avoid the sticking of freshly prepared concrete mix with the mould's surface.

The concrete mix is then filled in these moulds in layers. Each layer is tampered with a tamping rod. When the mould is filled to the top, it is place on the vibratory machine which helps in the compaction of the concrete by removing the voids in between. The top surface of the block is made smooth with the help of trowel. The mould along with the concrete is left untouched for 1 day. The mould is now opened to extract the concrete block which has attained stiffness. Fig 3.8. shows cast iron cube mould. Fig 3.9 shows greasing of moulds. Fig 3.10 shows tampering of layer by tamping rod. Fig 3.11 shows compaction of concrete using vibratory machine. Fig 3.12 concrete cubes in moulds.

Fig 3.8. Cast Iron Cube moulds

Fig 3.9. Greasing of moulds

Fig 3.10. Tampering of layer by tamping rod

Fig 3.11. Compaction of concrete using vibratory machine

Fig 3.12. Concrete cubes in moulds

3.8. Curing of concrete cubes

The casted concrete samples were demoulded after 24 hours. These cubes were then placed in a curing tank filled with clear water. The concrete cubes are placed such that they are completely submerged in the water. The temperature of the water in the curing tank must be maintained at 20°C. After the specified days these cubes are taken out of the tank for the testing of the compressive strength. Fig 3.13. shows curing of cubes in a curing tank.

Fig 3.13. Curing of cubes

CHAPTER 4
EXPERIMENTAL INVESTIGATION

4.1 Experimental Program

In order to study the interaction of recycled aggregate and plastic waste with concrete under compression, 4 cubes were casted respectively for each replacement. The program was carried out into three sections:

The first section is casting conventional concrete consisting of natural coarse aggregate with 0% replacement with RCA and plastic waste.

The second section involves casting of concrete with different proportions of RCA:
In this section the total volume of concrete cube consisting of natural coarse aggregate is replaced by various proportions like 30%, 50%, 70%, and 100% by volume fraction of recycled coarse aggregate.

The third section involves casting of concrete with different proportions of plastic waste keeping 50% volume fraction of natural coarse aggregate and 30% volume fraction of Recycled coarse aggregate of the total volume of concrete.
In this section the total volume of concrete cube consists of 50% natural coarse aggregate and 50% recycled coarse aggregate. This 50% recycled coarse aggregate is replaced by various proportions like 10%, 15%, and 20% of plastic waste.

4.2. Material used in experiment

4.2.1. Cement

For the experiment, we used Pozzolana Portland cement (PPC). The specific gravity of this cement was 3.15. The name of the manufacturer was “ULTRATECH”. Fig 4.1 shows cement used.

Fig 4.1. Cement used

4.2.2. Natural Coarse Aggregates:

We used natural coarse aggregate obtained from crushed stone whose maximum size was 20mm.The specific gravity these coarse aggregate was 2.59. Also the water absorption was found out to be 2.3%. Fig 4.2 shows natural coarse aggregate.

Fig 4.2. Natural coarse aggregates

4.2.3. Natural Fine Aggregate:

We used sand extracted from river which was easily available at a nearby village. The specific gravity of fine aggregate was 2.52 and the water absorption was 1.2%. Fig 4.3 and Fig 4.4 shows fine aggregates and sand respectively.

Fig 4.3. Fine aggregates

Fig 4.4. Sand

4.2.4. Recycled aggregate

The recycled aggregate was extracted from the demolition waste. The waste was collected and crushed into smaller pieces by hammering which consist aggregates along with mortar adhered on it. The mortar was removed as much as possible. The aggregates so obtained was sieved to acquire coarse aggregate of suitable dimension.

Fig 4.5 and Fig 4.6 shows the extraction of recycled aggregate and recycled aggregate respectively.

(a)

(b)

Fig 4.5. Extraction of recycled aggregate: (a) Crushing of demolition waste, (b) Sieving of crushed concrete

Fig 4.6. Recycled aggregate

4.2.5. Plastic Waste

Recycled plastic was collected from a plastic pipe manufacturing industry in the burnt form whose dimensions was between 10-15mm. Fig 4.7 shows plastic waste collected in a tray.

Fig 4.7. Plastic Waste

4.2.6. Silica Fume:

Silica fumes was used as a replacement of cement to enhance the binding property of the cement which in turn helps to increase the strength of the concrete. Silica fume was ordered from India mart where it was easily available. Specific gravity of silica fume: 2.2-2.5. Fig 4.8 shows Silica Fume

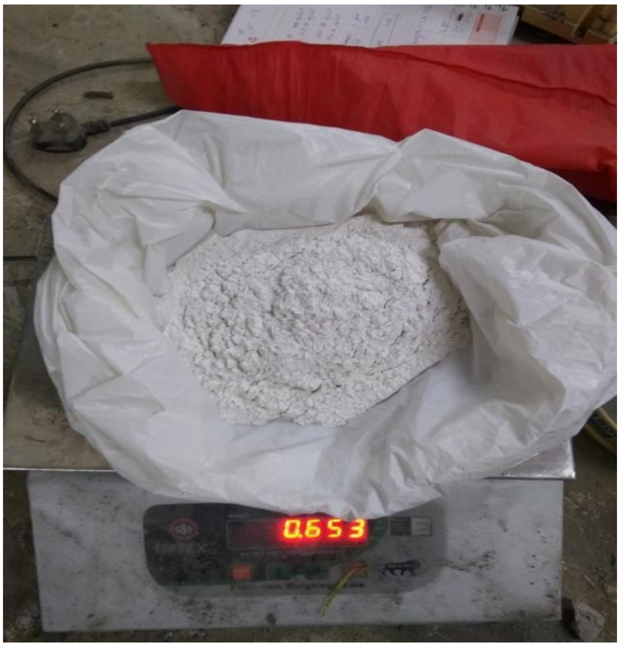

Fig 4.8. Silica Fume

4.2.6. Water

We used tap water of the laboratory for the preparation of the concrete mix. Fig 4.9 shows tap water used.

Fig 4.9. Tap Water

4.3. Casting Procedure

Using mix design 30, i.e. M30 grade, concrete cubes are prepared. For the concrete blocks, the mix was cast into four cubes of dimension 150 mm in size using steel moulds. The cast specimens consisting of the cubes and moulds were set aside in suitable temperature for 24 hours. After 24 hours the moulds were opened and cubes were extracted. These cubes were now placed in water for curing for the upcoming days. These cubes were then tested using a compression testing machine to obtain the 7 days and 28 days' compressive strength. Fig 4.10 shows the casting procedure.

Fig 4.10. Casting Procedure

CHAPTER 5
RESULTS AND DISCUSSION

The tests of physical and mechanical properties of cement were carried out. These tests included normal consistency test, initial and final setting time test, and specific gravity test. The cement that we used was Pozzolana Portland Cement(PPC). The results obtained are in accordance with IS 1489 (1991). The results are shown in Table 5.1 as under:

Table 5.1: Properties of Cement

Particulars	Results
Normal Consistency	31%
Initial Setting Time	72 min
Final Setting Time	435 min
Specific Gravity	3.14

The tests of physical and mechanical parameters of natural coarse aggregates were carried out. The results obtained are in accordance with IS 383 (2016). The results are displayed in Table 5.2 as under:

Table 5.2: Properties of natural coarse aggregate

Particulars	Results
Water absorption	2.3%
Specific Gravity of Coarse Aggregate	2.59

The tests of physical and mechanical parameters of natural fine aggregates were carried out. The results obtained are in accordance with IS 383 (2016). The results are displayed in Table 5.3 as under:

Table 5.3: Properties of natural fine aggregate

Particulars	Results
Water absorption	1.2%
Specific Gravity of Fine Aggregate	2.52
Zone of Fine Aggregate	II

Sieve analysis was done to determine zone of fine aggregate with mixing of 75% and 25% and results obtained are in the Table:5.4

Table 5.4 Fineness modulus of fine aggregate as per IS 383 (2016).

Sr. No.	Sieve Size	Weight retained (gm)	Passed weight (gm)	Passing percentage (%)
1.	4.75 mm	11.9	1986.6	99.4
2.	2.36 mm	419.5	1567.1	78.41
3.	1.18 mm	517.7	1049.4	52.5
4.	0.6 mm	293.5	755.9	37.8
5.	0.3 mm	193.3	562.6	28.15
6.	0.15 mm	496.8	65.8	3.2
7.	Pan	65.8	-	-
8.	Total	1998.5	-	-

Zone of Sand = II

5.1 Compressive strength of concrete with replacement of natural coarse aggregate with recycled coarse aggregate in various proportions.

According to the mix proportion of M30 grade, the target strength is calculated as 38.25 MPa. The concrete cubes were tested for compressive strength at 7 days and 28 days. The 7days compressive strength came out to be 27.73 MPa which is 72.49% of the target strength. Also, the 28 days’ compressive strength was found out to be 34.93 MPa which is 91.32% of the target strength. Table 5.5 shows the compressive strength of conventional concrete cubes for 7 days and 28 days. Also, Fig 5.1 displays graphical representation of this data which is given below:

Table 5.5 Compressive strength of concrete cubes with 0% replacement of natural coarse aggregates with recycled coarse aggregates.

0% Replacement of NCA	Load (kN)	Strength (MPa)	Load (kN)	Strength (MPa)	Avg.
7 days	620	27.56	628	27.91	27.73
28 days	782	34.75	790	35.11	34.93

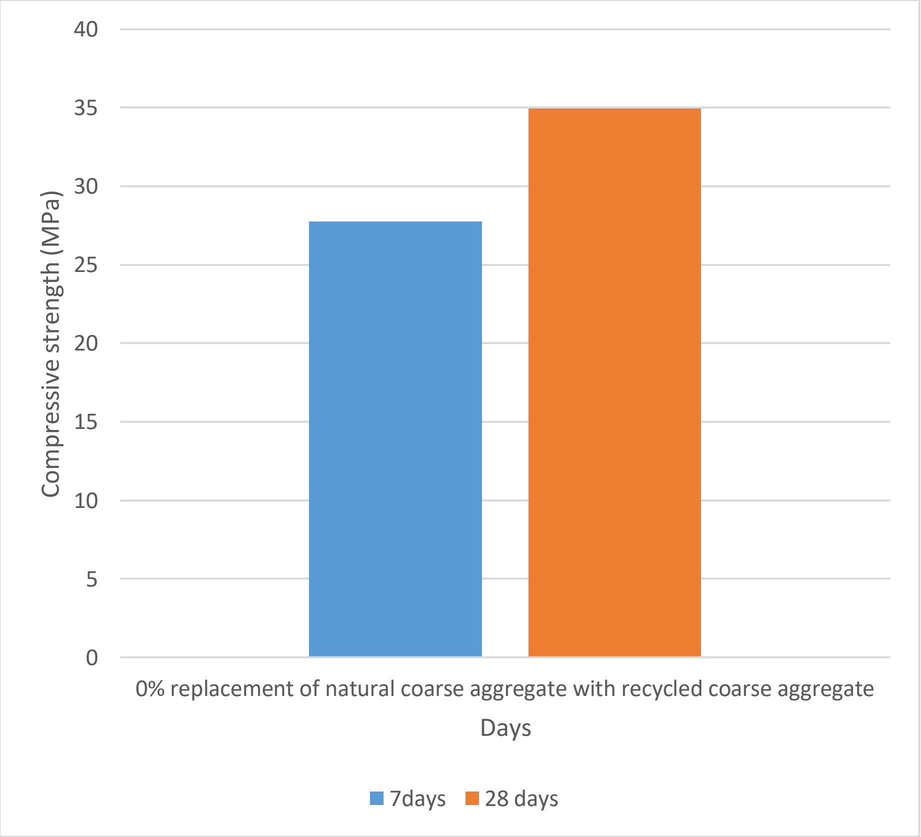

Fig 5.1 Compressive strength comparison of conventional concrete

The natural coarse aggregates were replaced with 30% by volume fraction of recycled coarse aggregates. Compressive strength tests were conducted at 7 days and 28 days. The 7 days' compressive strength came out to be 26.55 MPa which is 95.74% as compared to that of conventional concrete. Similarly, the 28 days' compressive strength was found out to be 32.57 MPa which is 93.24% as compared to that of conventional concrete. Table 5.6 shows the compressive strength of concrete cubes with 30%

replacement of natural coarse aggregates with recycled coarse aggregates.

Table 5.6 Compressive strength of concrete cubes with 30% replacement of natural coarse aggregates with recycled coarse aggregates.

30% Replacement of NCA	**Load (kN)**	**Strength (MPa)**	**Load (kN)**	**Strength (MPa)**	**Avg.**
7 days	603	26.80	592	26.31	26.55
28 days	729	32.40	737	32.75	32.57

Again, the natural coarse aggregates were replaced with 50% by volume fraction of recycled coarse aggregates. The 7 days' compressive strength came out to be 24.71 MPa which is 89.10% as compared to that of conventional concrete. Similarly, the 28 days' compressive strength was found out to be 31.42 MPa which is 89.95% as compared to that of conventional concrete. Table 5.7 shows the compressive strength of concrete cubes with 50% replacement of natural coarse aggregates with recycled coarse aggregates.

Table 5.7 Compressive strength of concrete cubes with 50% replacement of natural coarse aggregates with recycled coarse aggregates

50% Replacement of NCA	**Load (kN)**	**Strength (MPa)**	**Load (kN)**	**Strength (MPa)**	**Avg.**
7 days	552	24.53	560	24.89	24.71
28 days	702	31.20	712	31.64	31.42

Again, the natural coarse aggregates were replaced with 70% by volume fraction of recycled coarse aggregates. The 7 days' compressive strength came out to be 21.12 MPa which is 76.16% as compared to that of conventional concrete. Similarly, the 28 days' compressive strength was found out to be 29.46 MPa which is 84.34% as compared to that of conventional concrete. Table 5.8 shows the compressive strength of concrete cubes with 50% replacement of natural coarse aggregates with recycled coarse aggregates.

Table 5.8 Compressive strength of concrete cubes with 70% replacement of natural coarse aggregates with recycled coarse aggregates

70% Replacement of NCA	**Load (kN)**	**Strength (MPa)**	**Load (kN)**	**Strength (MPa)**	**Avg.**
7 days	470	20.88	481	21.37	21.12
28 days	657	29.20	669	29.73	29.46

Again, the natural coarse aggregates were replaced with 100% by volume fraction of recycled coarse aggregates. The 7 days' compressive strength came out to be 19.86 MPa which is 71.61% as compared to that of conventional concrete. Similarly, the 28 days' compressive strength was found out to be 26.97 MPa which is 77.21% as compared to that of conventional concrete. Table 5.9 shows the compressive strength of concrete cubes with 100% replacement of natural coarse aggregates with recycled coarse aggregates

Table 5.9 Compressive strength of concrete cubes with 100% replacement of natural coarse aggregates with recycled coarse aggregates

100% Replacement of NCA	**Load (kN)**	**Strength (MPa)**	**Load (kN)**	**Strength (MPa)**	**Avg.**
7 days	446	19.82	448	19.91	19.86
28 days	607	26.97			26.97

These results are displayed in a graphical representation as shown in Fig 5.2.

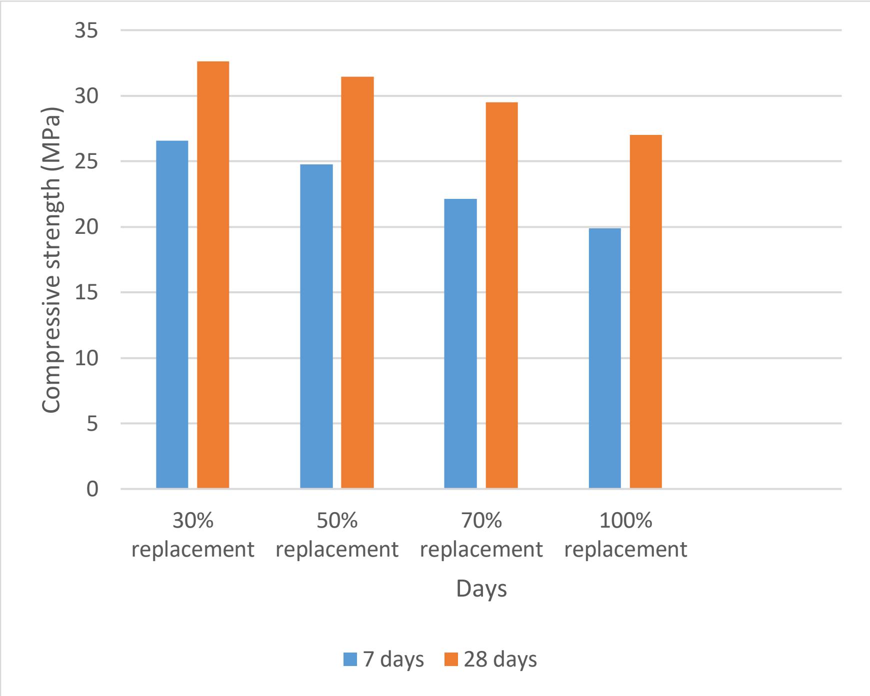

Fig 5.2 Compressive strength comparison of concrete with various replacement of natural coarse aggregate with recycled aggregate

5.2 Compressive strength of concrete with replacement of aggregates with plastic waste in various proportions

The replacement of RCA (which was 50% by volume of total aggregates) with plastic waste in various proportions are done keeping 50% of natural coarse aggregate constant. These replacements were done in proportions like 10%, 15%, and 20% volume fraction. Recycled coarse aggregate were replaced by the plastic waste. The results obtained of compressive strength for 7 days and 28 days are shown in tables below:

Table 5.10 Compressive strength of concrete with replacement of recycled coarse aggregates with 10% plastic waste by volume fraction

10% Replacement of RCA	Load (kN)	Strength (MPa)	Load (kN)	Strength (MPa)	Avg.
7 days	456	20.26	464	20.62	20.44
28 days	571	25.37	578	25.68	25.52

Table 5.11 Compressive strength of concrete with replacement of recycled coarse

aggregates with 15% plastic waste by volume fraction

15% Replacement of RCA	Load (kN)	Strength (MPa)	Load (kN)	Strength (MPa)	Avg.
7 days	413	18.35	425	18.88	18.61
28 days	526	23.37	538	23.91	23.64

Table 5.12 Compressive strength of concrete with replacement of recycled coarse aggregates with 20% plastic waste by volume fraction

20% Replacement of RCA	Load (kN)	Strength (MPa)	Load (kN)	Strength (MPa)	Avg.
7 days	331	14.71	344	15.28	14.99
28 days	458	20.35	469	20.84	20.59

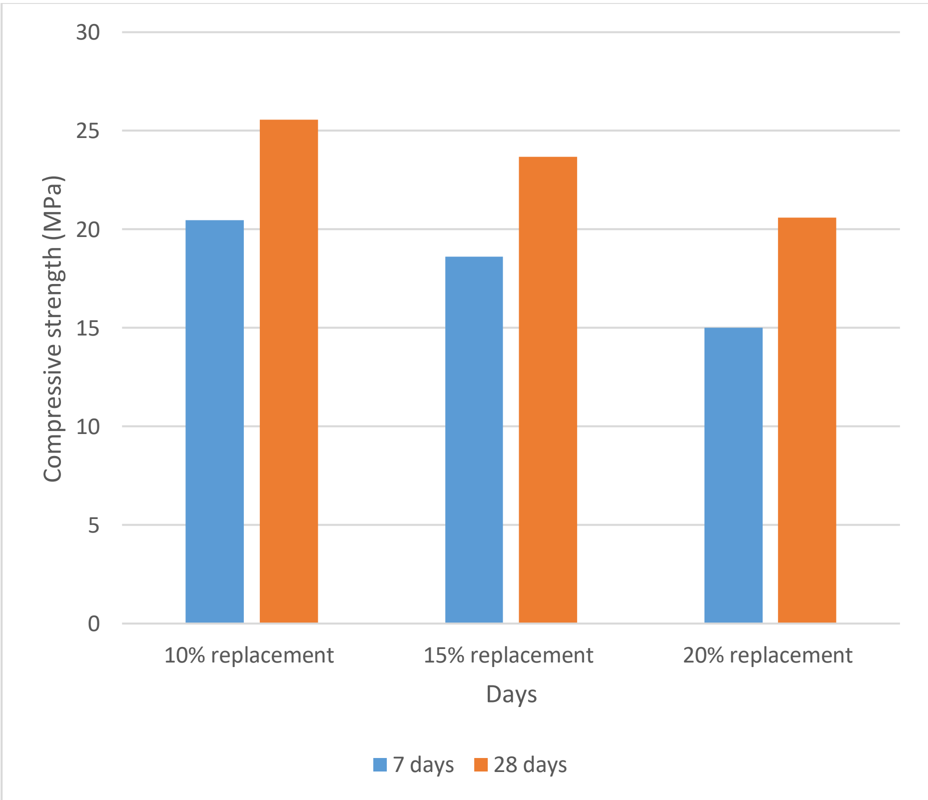

Fig 5.3 Compressive strength comparison of concrete with various replacement of recycled coarse aggregate with plastic waste.

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

6.1 CONCLUSIONS

The primary motive of this research was to examine the possibility of incorporating waste into the construction industry, more precisely, into concrete manufacturing. The point was to build up if RA and PW can fill in as an increasingly maintainable choice to concrete production.

The most important aspect of concrete production is the compressive strength. This research work has concentrated highly on the tests determining the compressive strength of concrete. The tests conducted in this research have totally or partially replaced natural aggregate by recycled aggregate for the generation of a new concrete with altered mechanical properties. Results showed that the mechanical properties of reused concrete are significantly reliable on the nature of the waste material that was used to make the economical concrete. The more inhomogeneous the RA, the more it is difficult to handle its application to concrete production.

Overall, it was observed that it is feasible to use waste materials in the production of concrete. If more RA as an element in concrete are utilized, less natural aggregates will be used. Thus, the negative effect of removing aggregates is diminished. Besides, reprocessing waste materials in the structure of concrete gives a partial answer for the consistently developing issue of waste disposal.

From the above results we can show that:

- The compressive strength of M30 design mix concrete comprising Recycled aggregate has a significant decrement for high volume replacement of Recycled coarse aggregate. Hence high volume replacement is not advisable.
- 30% replacement of Natural coarse aggregate(NCA) with Recycled coarse aggregate(RCA) is advisable.
- There was a significant reduction in compressive strength when replacement with plastic waste was done. This was because of the low bonding between plastic waste and cement paste.
- 10% replacement of aggregates with plastic waste is advisable.

6.2. FUTURE SCOPE

Later in the future, it would be beneficial to perform Life Cycle Assessments on RA so as to build up if the utilization of RA gives a progressively maintainable way to deal with in a construction industry. Use of recycling plastic waste and recycled coarse aggregates can't be taken as the best alternative. It is evident that that the strength of the concrete decreases when these waste materials are used. So, we cannot use them for structural applications but there are other sectors in Civil engineering like construction of gutters, pavements, etc. where this type of concrete can be suitable option. Also, there must be a proper information that gives us an idea that reusing waste into concrete really helps to increase ecological assurance. For real, it may not be reasonable to gather, treat and transport RA from long distances to the end use site if there is an availability of enough natural aggregates

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