EFFECTS OF WASTE MATERIAL ON MECHANICAL PROPERTIES OF CONCRETE MIX

A

PROJECT REPORT

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

of

BACHELOR OF TECHNOLOGY

IN CIVIL ENGINEERING

Under the supervision

of

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STUDENT'S DECLARATION

I hereby state that the project report titled "**EFFECTS OF WASTE MATERIAL ON MECHANICAL PROPERTIES OF CONCRETE MIX**" submitted in partial fulfilment of the requirements for the Bachelor of Technology degree in Civil Engineering at the Jaypee University of Information Technology, Waknaghat is an authentic record of our work conducted under the supervision of **Dr. Amardeep**. This work has not been submitted for any other degree or credential consideration. Our project report's content is entirely our Authority.

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CERTIFICATE

This is to certify that the work presented in the project report titled "**EFFECTS OF WASTE MATERIAL ON MECHANICAL PROPERTIES OF CONCRETE MIX**" submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat in partial fulfilment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering is an authentic record of work carried out by **Sumit Chahar (191608), Hardik Dhillon (191609)** and **Akhil Janawa (191614)** under the supervision of **Dr. Amardeep** is an authentic record of work carried out and the preceding statement is correct, to the best of our knowledge.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Page No.

ABSTRACT

For the current economic and environmental challenges, resilient pavement infrastructure is essential. The accelerated growth of the global social economy over the last ten years has been greatly aided by the pavement infrastructure. As concrete is the most useful thing in the construction industry. The environment gets affected in one or other way because of the raw materials used in the manufacturing of concrete. For example, Manufacturing of cement produce CO_2 and the production of aggregates results in emergence of dust in the environment and affects the geology of that particular area. That's why field of pavement engineering is seeing the emergence of new ideas, methodologies, technologies, and materials over past some years. Disposal of plastics in large quantities causes several health and environment related issues which warrants to propose different measures to utilize plastic in different construction practices may result in sustainable environment a help in reducing carbon footprint also. This work investigates about usefulness of waste products in the concrete along with the components of concrete as a step towards reduction of environmental pollution as well as to solve the problem of disposal till some extent of those substances. Many of these substances are already in use like Silica Fume, Fly ash etc. Here Plastic Aggregate were used as a replacement of conventional coarse aggregates along with Electric Arc Furnace (EAFS) Slag as a replacement of cement and fine aggregate.

Plastic aggregates used were made by collecting low density polyethylene (LDP) plastic followed by heating them till softening point and chopping them in small pieces, following that plastic aggregates were sieved and the particles which passed through 20mm sieve and retained on 12.5mm sieve were used for the study. Samples were prepared for plastic aggregate as percentage of 10%, 20%. 30%, 40% and 50% as a replacement of coarse aggregate and fine aggregate. Several cubes and beams having size of 150*150*150mm and 100*100*500 mm respectively were casted by following guidelines of Indian standards (IRC 44:2019) and left for different curing time period i.e.7,14 and 21 days. In order to find the optimum percentage of plastic aggregates that can replace the conventional aggregates and fine aggregates in concrete without losing the strength of concrete or compromising any of its properties. On the basis of findings, it was revealed that the replacement of plastic aggregates (PA) in concrete mix will result in reduction in compressive strength of concrete. Though, 30% of plastic aggregates as the replacement of conventional aggregates can be done in order to construct a

low traffic carrying highways as 33.2 MPa strength was observed during the experimental analysis (IS SP 62:1997).

The use of slag in concrete as a fine aggregate and as a replacement for cement has gained attention as the sustainable and cost-effective alternative to conventional materials. Several studies have investigated the effects of using slag in concrete, with varying results. Studies have shown that using slag as a fine aggregate can improve the workability and mechanical properties of concrete, such as compressive strength and flexural strength. This study explores the use of Electric Arc Furnace (EAF) steel slag as a replacement for both fine aggregate and cement in concrete. The primary objective is to evaluate the potential of EAF steel slag to enhance the mechanical properties and durability of concrete while reducing the environmental impact of its production. The study investigates the physical and mechanical properties of EAF steel slag and compares them to those of natural fine aggregate and cement. The mix proportions of concrete containing different percentages as 10%, 20%, 30%, 40% and 50% of EAF steel slag as a replacement for fine aggregate and cement following casting of several cubes of size 150*150*150mm and beams of size 100*100*500 for compressive test and flexural test respectively by following guidelines of Indian standards (IRC 44:2019) and left for different curing time period i.e. 7,14 and 21 days. The results indicate that the incorporation of EAF steel slag in concrete improves its compressive strength, flexural strength of concrete, Moreover, the use of EAF steel slag reduces the consumption of cement, resulting in lower carbon dioxide emissions and energy consumption during the production of concrete. The study concludes that EAF steel slag can be used as a sustainable alternative to natural fine aggregate and cement in concrete without compromising its mechanical properties and durability.

CHAPTER – 1

INTRODUCTION

1.1 GENERAL

Economy of any country depends upon a good infrastructure which covers roads, bridges, warehouses, airports etc. In all the construction related activities most commonly used material is concrete which is mainly is a mixture of cement, water, and aggregates such as sand, gravel, or crushed stone. Though, it is an environmental concern because of emission of several hazardous gasses of cement manufacturing process and blasting done in crushing of aggregate. Also, cement is the second most consumable material after water around the world. In Civil Engineering Construction, there has been a drastic increase in the usage of finely ground plastic waste in place of coarse aggregates. Waste is being incorporated into concrete because employing plastic aggregates has additional environmental and potential economic benefits. Using energy recovery, plastic can be burned if material recycling is not possible. possible. The use of plastic waste as an aggregate in concrete production is a promising approach to tackle the issue of plastic waste management while contributing to sustainable construction practices. Plastic waste can be used as a partial or complete replacement for conventional aggregates, such as sand., gravel, or crushed stone. Overall, the use of plastic waste as an aggregate in concrete production presents a promising approach to tackling the issues of plastic waste management, while contributing to sustainable construction practices. Further research is needed to address the potential challenges associated with this approach and to optimize the properties and performance of plastic waste concrete.

Steel slag is a byproduct of the steel industry and is generated during the process of manufacturing steam. It is a highly sustainable material that can be used as a replacement for natural aggregates in concrete production. Steel slag has several beneficial properties, such as high strength, low porosity, and good wear resistance, which make it an attractive alternative to traditional aggregates. The use of steel slag in concrete has been extensively researched, and several studies have demonstrated its potential to enhance the mechanical and durability properties of concrete. Steel slag can be used as a partial or complete replacement for natural aggregates, including fine aggregates (sand) And coarse aggregates (gravel or crust stone). Overall, the use of steel slag in concrete production presents a sustainable and environmentally.

friendly approach to the use of aggregates in construction. However, further research is needed to optimize the properties and performance of steel slag concrete and to address any potential challenges associated with its use.

1.2 INTRODUCTION

Concrete is a fundamental construction material used extensively in building and infrastructure projects. However, traditional concrete production methods require significant amounts of natural resources, resulting in environmental degradation and depletion of resources. The global cement industry produces over four billion tons of cement annually. Over four billion tons of cement are produced annually by the global cement industry. According to the most recent information from the Indian Bureau of Mines (2015), 0.83 to 43.8 million tons of cement are produced in India each year by various enterprises. Among the waste products that can be recycled and used again as part of a polymer concrete mix to cut down on the need for regular Portland cement (OPC) and increase energy efficiency without harming the environment are fly ash, steel slag, E-plastic, and recycled concrete aggregate. Some waste materials should be used to maintain environmental sustainability while protecting natural resources. However, some recommendations have been made with regard to the use of fly ash in construction of roads. As natural resources are not unlimited there is a need to find out alternative of cement and coarse aggregates while not compromising the standard values of conventional concrete mix. Therefore, researchers and industry professionals are exploring sustainable alternatives for concrete production. One promising approach is the use of byproducts., waste materials, and recycled materials as concrete components. As a result, academics and business experts are looking at sustainable ways to make concrete. Utilizing steel slag, a by-product of the steel industry, is one such solution. EAF steel slag mainly consists of FeO (10-40%), CaO (22-60%), SiO_2 (6-34%), Al_2O_3 (3-14%), and MgO (3-13%). Steel slag can be used in the manufacturing of concrete in two different ways as a fine aggregate and as a cement substitute also. The use of EAF steel slag as a raw material in other industries, such as cement production and agriculture, has been shown to reduce the environmental impact of these processes by decreasing the need for natural resources and reducing greenhouse gas emissions. When used as a substitute for traditional raw materials in cement production, EAF steel slag can reduce the amount of limestone and other minerals required, which can reduce greenhouse gas emissions by up to 50%. Furthermore, the economic benefits of using EAF steel slag are significant. The use of EAF steel slag has potential to reduce the cost of raw materials, as well as the cost of waste disposal. The production of EAF steel slag generates a significant amount of waste, which can be costly to dispose of. However, by using EAF steel slag as a substitute for traditional materials, the amount of waste generated can be reduced, and the cost of waste disposal can be minimized.

Due to its difficulty in biodegrading, plastic trash has grown to be a significant issue that is harming the ecosystem. The population is expanding and people's fundamental requirements are rising along with it every year, which leads to greater production and a rise in plastic trash. One way to reduce the amount of plastic trash is to recycle it and turn it into something useful. If used plastic is not properly recycled, it will end up in landfills and as trash in the countryside. As per the report of National Environment Program, 7.70 million tons of plastic garbage were produced in 2017. Of the top 8 nations with the most plastic waste in the world, Malaysia is the worst. Therefore, main aim of study is to use plastic aggregate as a coarse aggregate replacement in concrete mix

The expansion and extending of roads and highways force an overexploitation of the environment's natural resources. Today, finding substitute materials is essential to preserving the environment and halting the depletion of priceless natural resources. The past and the present can both be referred to as the "plastic era" due to the massive amount of plastic that has been manufactured for a variety of uses in all sectors of society. It is currently very difficult to imagine a future without plastic due to its usefulness, availability, and cost. As plastic is a non-biodegradable material, trash disposal is very difficult. Strict laws are in place to regulate the use of plastics in both amount and quality. due to their disposal problems, harmful impacts on the environment, and living beings. Plastic waste can be sourced from a range of materials, including single-use plastics, packaging materials, and other plastic products that would otherwise end up in landfills or oceans. The plastic trash was first procured then softened by heating and followed by shredding into small pieces and sieved according to requirement to be used as a substitute for coarse aggregate in the concrete mix. The properties of plastic waste as a building material have been extensively studied, including its strength, durability, and environmental impact. The results of these studies have shown that plastic waste can be a viable alternative to traditional building materials in some applications. Plastic waste can be sourced from a range of materials, including single-use plastics, packaging materials, and other plastic products that would otherwise end up in landfills or oceans. The plastic waste is first shredded into small pieces and then used as a substitute for coarse aggregate in the concrete mix. The properties of plastic waste as a building material have been extensively studied, including its strength, durability, and environmental impact. The results of these studies have shown that plastic waste can be a viable alternative to traditional building materials in some applications.

Moreover, the use of plastic waste in concrete production can reduce the need for Virgin materials and can contribute to reducing the overall environmental impact of concrete production. By diverting plastic waste from landfills and utilizing it as a construction material, the carbon footprint associated with both plastic waste management and traditional concrete production can be reduced. Plastic aggregates which are used in the study were procured from a local dealer and are male of LDP plastic melted and clopped off as per requirement.

The current study aims to establish a standardized value up to which plastic waste can be utilized as a partial replacement for coarse aggregates and slag as a replacement of fine aggregate and as a cement replacement can be done without affecting requisite properties of concrete. For that, various materials were procured from different states, including Himachal Pradesh and Haryana.

1.3 OBJECTIVES

1. To study the chemical and physical properties of waste materials and sustainable utilization of waste.
2. To check the combined strength of plastic aggregates in combination with EAF steel slag
3. To propose an alternative of cement and aggregates without compromising its properties.
4. To compare properties of concrete incorporating slag and plastic aggregate with conventional concrete.
5. To determine optimum percentage of plastic and slag as partial replacement of fine aggregate cement t in concrete mix design.

CHAPTER - 2

LITERATURE REVIEW

2.1 GENERAL

The use of traditional natural aggregates in concrete production has resulted in a significant depletion of natural resources and environmental degradation. This has led to the exploration of alternative materials as replacements for traditional aggregates in concrete production. In recent years, researchers have shown interest in the use of plastic waste and slag as alternative materials for concrete production. Plastic waste and slag have become major environmental issues due to their non-biodegradability and high disposal cost. Hence, utilizing these materials in concrete production not only helps in reducing waste but also contributes to sustainable development. The use of plastic waste and slag as aggregates in concrete production also has the potential to improve the mechanical properties of concrete. Several studies have investigated the use of plastic waste and slag as aggregates in concrete production, and the results have shown that the use of these materials can lead to improvements in compressive strength and flexural strength of the concrete. This literature review tries to give a thorough summary of the currently conducted studies and knowledge on the use of plastic aggregate as coarse aggregate and slag as fine aggregate replacement in concrete. The review will focus on the mechanical properties, durability and environmental impact of concrete produced with plastic aggregate and slag. It will also highlight any gaps or limitations in the existing literature and provide directions for future research in this area

2.2 LITERATURE REVIEW

Wangmo et al. (2017) carried out a study by using coarse aggregate made of plastic in concrete. The mechanical characteristics of concrete incorporating plastic particles were tested. The use of plastic aggregates in proportions of 10%, 15%, and 20%. and discovered a slight loss in strength and advised that 15% replacement would be the ideal outcome.

Kumar et al. (2018) carried out a study on use of plastic as partial replacement of fine aggregate in concrete. River sand, crushed aggregates, and OPC 53 grade were employed. In proportions of 10%, 20%, and 30%, they substituted plastic for fine particles. On the concrete samples, test was carried out on the mechanical and durability qualities. discovered the decline in concrete strength. However, it has been shown that concrete has become more elastic and exhibits good resistance to acid attacks. Accordingly, to the results the conclusion that plastic aggregate concrete can be employed in locations where reduced compressive strength but more durability is required.

Jaivignesh et al. (2017) carried out an experiment by using plastic waste as coarse aggregates and fine aggregates in proportions of 10%, 15%, and 20% using plastic as a replacement for the natural materials. In addition, steel fiber was added to the concrete. The study came to the conclusion that strength was declining, but the final conclusion was made to recommended using it to support the use of eco-friendly and less wasteful resources.

Hossain et al. (2016) did research by using discarded plastic as a component of concrete. by replacing coarse aggregates in the proportions: 5%, 10%, and 20.5and came to outcome that concrete was light weight than expected, but compared to typical concrete, the compressive strength was lower. Additionally, and discovered that concrete with 10% plastic particles has strength that is almost identical to that of regular concrete. 10% plastic aggregates produced the best results.

Raghatate et al. (2012) examined the effect of plastic bags as the reinforcement on the concrete mix properties i.e., compressive strength, and split tensile strength. In accordance to the weight of such concrete, he adds fiber in the amounts of 0.2%, 0.4%, 0.6%, 0.8%, and 1%.and discovered that while compressive strength decreased as plastic percentage increased, tensile strength increased, reaching its peak at 0.8% addition.

Vanitha et al. (**2015)** used plastic aggregates as both coarse and fine aggregate using concrete of the M20 grade to cast Paver Blocks and Solid Blocks with dimensions of 200 mm X 150 mm X 60 mm and 200 mm X 100 mm X 65 mm. These blocks underwent strength tests after 7, 14, and 28 days. In an equal replacement of aggregates, plastic was added to a ratio of 2%, 4%, 6%, 8%, and 10%. At 4% replacement of aggregates with plastic aggregates, and discovered that the paver block that produced the best results. Additionally, solid blocks include 2% plastic.

Rai et al. (**2012**) analyzed the effect of plasticizer-infused concrete made from waste plastic. In order to test the concrete with and without plasticizers, the mixed of M30 grade concrete with plastic pallets in varied proportions. with increase in the number of plastic pallets by the weight of concrete by 5%, 10%, and 15%, respectively. In order to get low density or light weight concrete, and discovered that there was a reduction in density. And also, there was a decrease in slump, which impacts the workability, but the problem is fixed by the addition of plasticizers. Although find a very slight decrease in compressive and flexural strengths, which can be tolerated.

Osei et al. (**2014**) carried out research by using flexible plastic aggregate by substituting 25%, 50%, 75%, and 100%, by plastic for the coarse aggregates in concrete with the ratio 1:2:4. In this research, the discovery was made that both concrete's density and strength had decreased. And claimed that concrete for structural use should not have aggregate replacement rates greater than 36%. In addition, they recommended using plastic to create lightweight concrete.

Subramani et al. (2015) performed analysis by using plastic waste as coarse particle replacement in 5%,10% and 15% in concrete. The study concluded that concrete gave best results at 10% replacement of coarse aggregates by plastic waste as an aggregate.

Brito et al. (**2012)** investigated the use of plastic aggregate as the replacement of coarse aggregate and fine aggregate in concrete mix and cement mortar respectively and discovered that using plastic aggregates with angles reduces workability whereas using aggregates with flat edges boosts it. No of the type of plastic, there was a drop in compressive strength, but flexural and tensile strength were only slightly affected.

Amalu et al. (**2016**) carried out the investigation on the usage of waste plastic as fine aggregate in concrete. In proportions of 10%, 15%, 20%, and 25%, and substitute plastic for fine aggregates. discovered a decline in concrete's strength, but the encourage to use of plastic in non-structural concrete because it exhibits higher workability and produces less environmental waste.

Jibrael M.A. and Farah P. et al. (2016) did analysis on structural behavior and strength of concrete containing waste plastic. Plastic bags and bottles were used in concrete in varied amounts, ranging from 0% to 5%, to replace fine particles. and came to the conclusion that since it weakens the material in both situations, plastic should only be used in non-structural applications of concrete.

Hazra et al. (2022) conducted a study using machine learning to examine the effectiveness and durability of sustainable concrete made from waste plastic as an aggregate. and discovered that concrete's workability had increased, its density had decreased, and its compressive and tensile strengths had been reduced to a tolerable level. and come to the conclusion that plastic aggregates should not be employed for structural purposes since they reduce mechanical strength.

Mehta et al. (2018) studied the strength and permeability of sustainable geopolymer concrete using ground granulated blast furnace slag (GGBS). It was discovered through research that at 90 days, 85% GGBS yields a maximum compressive strength of roughly 69MPa. and the microstructural characteristics demonstrated that GGBS-based geopolymer concrete compositions with calcium silica hydrates and sodium alumina sulphate coexisted, enhancing the strength qualities.

Awoyera et al. (2019) studded alkali activated slag as a sustainable composite binder, found that sodium carbonate was the most effective activator because it produced materials with strength comparable to those activated with sodium hydroxide and sodium silicate and had good fresh qualities that would make their large-scale use feasible. It produces superior fresh properties that would allow for its broad use.

Junaid et al. (2018) gave results of a study on the qualities of fly ash-based geopolymer concrete that included at room temperature and used just 100% raw waste as a binder have been published. Workability, water absorption, compressive, splitting tensile, and flexural strengths of alccofine activated geopolymer concrete have all been investigated according to Indian Standards. In order to ascertain the phase, composition, and microstructural characteristics of the produced samples, X-ray diffraction (XRD) and scanning electron microscopy (SEM) investigations were conducted. The findings demonstrate that geopolymer concrete made with alum at room temperature not only has better physical characteristics, but is also encouraged to take the place of traditional concrete.

Mathew et al. (2013) concluded that 22% of plastic aggregate may be utilized as the replacement of coarse aggregate. Though, fire resistant property of the mix was decreasing with increase in plastic aggregate content in concrete.

Kavyateja et al. (2020) conducted a study by partially replacing cement with alumina and fly ash in self-compacting concrete. The results are presented in this report. In SCC mixes, fly ash (i.e., 25%) and alccofine (5, 10 and 15%) were used in place of cement. Testing was done to determine the SCC's compressive strength, split tensile strength, and rupture modulus. Results showed that adding 25% fly ash and 10% alcofine to self-compacting concrete enhanced its compressive strength, split tensile strength, and rupture modulus at all curing ages.

Basha et al. (2020) did a study that by using recycled plastic aggregates to evaluate mechanical and thermal properties of concrete samples in varying percentage of recycle plastic aggregates. The results showed that the compressive strength and split tensile strength decreased as the percentage of recycled plastic aggregate increased. However, the use of plastic aggregate in concrete did not significantly affect the flexural strength of the samples. The study also found that the conductivity of concrete decreased with the increase in the percentage of recycled plastic aggregates. The article concludes that the use of recycled plastic aggregates in concrete can reduce the weight of the concrete, while also improving its thermal properties.

Aldahdooh et al. (2018) examined the compressive strength, tensile strength, and flexural strength of concrete samples with varying percentages of plastic waste aggregates. The results indicate that the compressive strength of the concrete decreases as the percentage of plastic waste aggregates increases. However, the use of plastic waste aggregates does not significantly affect the tensile and flexural strengths of the samples. The study also found that the water absorption capacity and permeability of the concrete decreased with the increase in their percentage of plastic waste aggregates. The article concluded that the use of plastic waste aggregates in normal concrete is feasible and can contribute to reducing plastic waste while improving some properties of the concrete. However. The reduction in compressive strength may limit the application of plastic waste aggregates in structural concrete.

Guo et al. (2018) conducted a study that showed that the compressive strength and split tensile strength of the concrete decreased as the proportion of steel slag increased. However, the impact resistance of the concrete increased as the proportion of steel slag increased, indicating that the steel slag can improve the toughness of the concrete. Also, the optimum replacement percentage of steel slag as a fine aggregate was found to be 20%.

Roslan et al. (2016) conducted a series of laboratory experiments to prepare concrete mixes with varying proportions of steel slag and steel sludge as a partial replacement for fine and coarse aggregates. The tests included compressive strength, tensile strength, water absorption, chloride ion penetration, and microstructural analysis. The results of the study showed that the edition of steel slag and steel sludge in concrete can enhance its mechanical properties, such as compressive tensile strength. Moreover, the use of these materials can reduce the water absorption and chloride and penetration of concrete, which can improve its durability. The best dosage was found to be 10%, but highest compressive strength was achieved at 20% replacement of slag as a fine aggregate.

Xu et al. (2021) investigated the effects of replacing cement with steel slag at different ratios on the mechanical and durability properties of concrete. The results showed that the use of steel slag as a partial replacement for cement can improve the mechanical properties of the concrete, as well as resistance to chloride ion penetration and sulphate attack.

Azad et al. (2019) investigated the use. Of steel slag as fine aggregate in concrete. The study found that the use of steel slag as a fine aggregate replacement led to an increase in the compressive strength of concrete, and improved workability and durability of concrete.

Danilo et al. (2019) examined the use of EAF slag as the raw material for the production of geopolymer -based cement and found that the use of electric arc furnace slag led to an increase in compressive strength and reduced environmental impact compared to traditional cement.

Mohammed et al. (2019) utilized copper slag as fine aggregate in concrete and examined the mechanical properties of concrete such as compressive strength, flexural strength and concluded that with increase in slag percentage there was an increase in compressive strength of concrete.

2.3 GAP IDENTIFICATION

On the basis of literature survey, following gaps have been identified:

1. On the basis of literature, very limited studies were found on the usage of plastic aggregate as replacement of coarse aggregate in concrete
2. Although the use of steel slag in concrete has been described in the literature, but limited work has been recorded on the optimization of slag in concrete.
3. Most of the studied were recommending the use of plastic aggregate in non-structural building construction practices.
4. Indian standards do not specify any standard value regarding the use of plastic aggregate and EAF steel slag as a replacement of coarse aggregate and fine aggregate respectively.
5. There is currently no standard replacement value for the use of Steel slag as fine aggregate and as a cement replacement in concrete.
6. In most of the studies maximum percentage of slag replaced as a fine aggregate varies between 10-20%.
7. No study has reported the use of plastic aggregate in combination with slag as partial replacement of cement and fine aggregate in concrete.

CHAPTER - 3

METHODOLOGY OF THE STUDY

3.1 GENERAL

In this chapter, examination of approaches that will be used in the effort to utilise waste plastic and EAFS in concrete and contrast the strengths and qualities of both mixes, i.e., conventional mix and other mix with plastic aggregates and EAFS. Consequently, the determination of characteristics of plastic aggregates and slag to determine if they can be used for construction purposes or not.

3.2 MATERIALS

All the materials required for the experiment (Fig. 3.1) were procured form different cities. OPC43 cement, LDP plastic aggregates and EAF steel slag were procured from a local dealer shop, a plastic factory and Jindal steel limited factory respectively from Hisar, Haryana. Conventional coarse aggregate and fine aggregate were provided by university in Himachal Pradesh.

(a)

(b)

(c)

(d)

Fig. 3.1 (a) OPC 43, (b) Coarse Aggregates, (c) Fine Aggregates, (d) Plastic Aggregates

3.2.1 Cement (OPC):

Ordinary Portland cement, commonly referred to as simply "ordinary cement," is a hydraulic binder created by mixing Portland cement clinker, blended components ranging from 6% to 15%, and the appropriate quantity of gypsum using OPC-43.

3.2.2 Aggregates:

i. **Coarse Aggregates: -**

Stones or rocks which are crushed or fractured into small pieces and have irregular shape and size are referred to as coarse aggregate. Aggregates of different varieties, including limestone, granite, and river aggregate, are used in construction projects.

Coarse aggregate is referred to as material with a size more than 4.75 mm or that passes through a 4.75 mm IS Sieve. Coarse aggregates are substances whose maximum size can reach 63 mm and are large enough to be retained on a sieve with a 4.75 mm mesh size. Coal, lignite, soft pieces, and clay lumps should not make up more than 5% of the total weight of coarse aggregate.

ii. **Fine Aggregates: -**

Fine aggregates are essentially any naturally occurring sand grains that have been mined from the earth. Fine aggregates are made out of natural sand or any shattered stone pieces that are 14" or smaller. This product is usually referred to as 1/4'" minus when discussing the size, or grading, of this specific aggregate.

Sand is a fine aggregate while crushed stone or metal is a coarse aggregate; both terms refer to aggregates that are less than 4.75 mm. The largest size employed is 80 mm, and the range from 80 mm to 4.75 mm is known as coarse aggregate, while the range from 4.75 to 150 m is known as fine aggregate.

iii. **Plastic Aggregates: -**

Polymer and filler were the primary components employed in the production of RPA. A local provider who collects and treats all forms of waste plastic from the neighborhood provided the LLDPE plastic aggregates made by chopping the plastic in small pieces. Then they were sieved according to requirement i.e., 20mm pass and 12.5mm sieve retained.

iv. **Electric Arc furnace slag: -**

EAF (Electric Arc Furnace) steel slag is a byproduct of steel production that occurs during the melting and refining of scrap metal in an electric arc furnace. The EAF steel-making process involves melting down the scrap metal in an electric arc furnace and then adding various agents to remove impurities from the molten metal.

During this process, slag is formed as a byproduct of the chemical reactions between the impurities and the added agents. EAF steel slag is typically composed of calcium, iron, silicon, and aluminum oxides, and is generally granular in nature.

3.3 METHODOLOGY OF THE STUDY

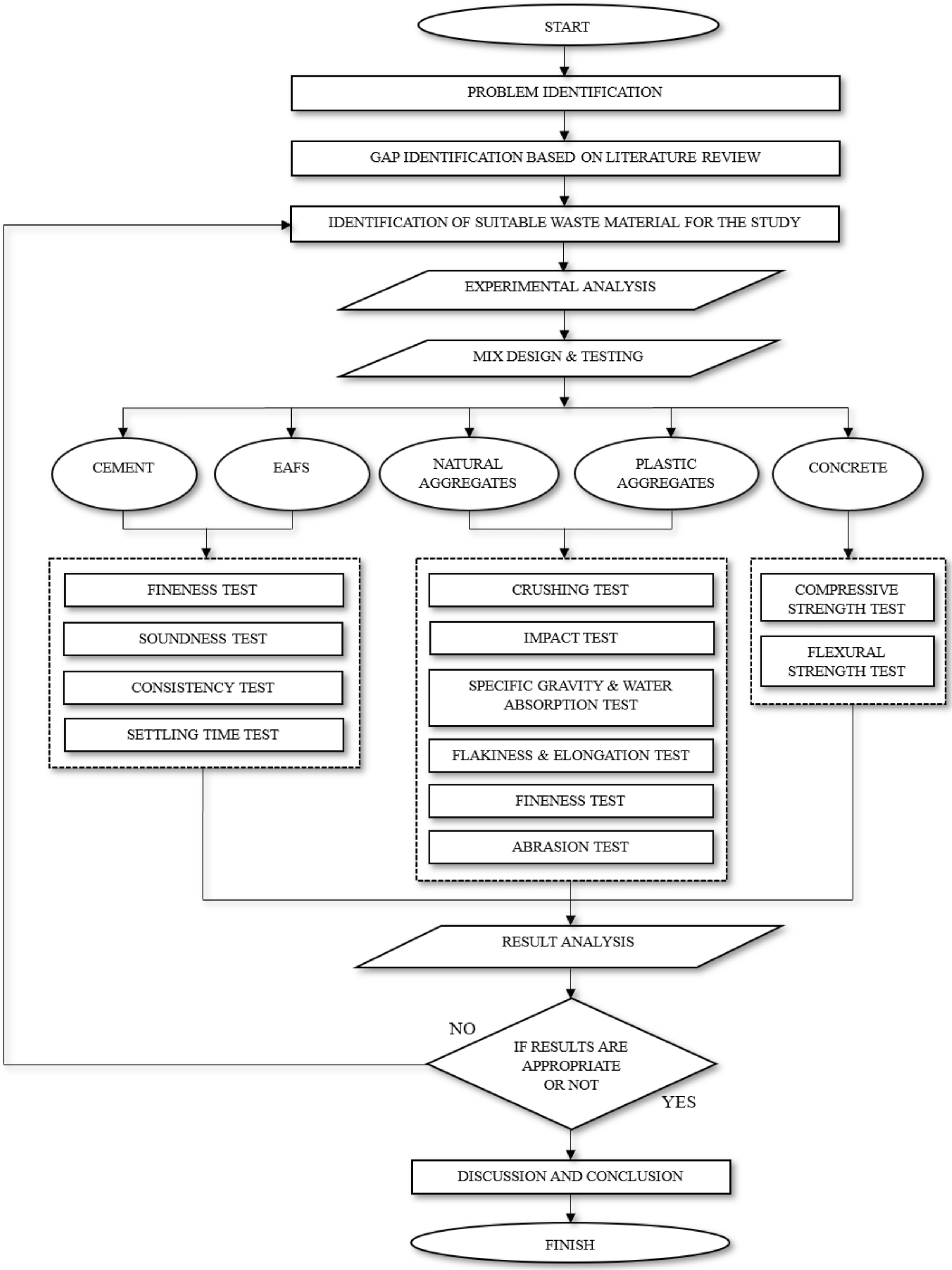


Fig 3.2 Methodology Flow Chart

3.4 TESTING OF MATERIALS

3.4.1 Tests for Ordinary Portland Cement (OPC):

i. Fineness Test: -

Cement was tested for fineness in accordance with IS code 4031 Part 1. The IS standard sieve was used to test the cement's fineness after passing 100g of cement through it. As shown in fig. 3.3, the weight of cement particles larger than 90 microns and the percentage of retained cement particles were determined. Equipment for the test included a lid, a pan, a 90-micron sieve, and a weighing scale. The Fineness Test Sieve is made of stainless-steel No. 325 wire cloth and a single-piece brass frame.

Fig 3.3 Fineness Test (IS Standard Sieve)

ii. **Settling Time Test: -**

The Settling Time Test of cement was performed as per code IS code 4031 Part 5 to determine the initial and final settling time as shown in fig 3.4. It is the period of time that elapses between the addition of water to the cement and the point at which the paste has become sufficiently solid to withstand a specific amount of pressure. For OPC cement, it should not exceed 600 minutes. Apparatus used for this test are Vicat apparatus, a weighing scale, a stopwatch, a gauge, and a Tray.

Fig 3.4 Settling Time Test (Vicat Apparatus)

iii. **Consistency Test: -**

The Consistency Test of cement was performed as per IS code 4031 Part 4. The cement's consistency was determined by mixing water with cement and wait for cement paste. Then, the vicat mould was filled with the cement paste and compaction was done till the top of the mould and the readings were taken on the vicat measuring scale as shown in fig 3.5. Apparatus used in this test are Vicat apparatus, vicat mould, weighing balance, measuring cylinder, glass plate, stop watch.

Fig 3.5 Consistency Test

3.4.2 Test for Aggregates

i. Crushing Test: -

The Crushing Test of coarse aggregates was performed as per IS code 2386. The aggregate crushing test is used to determine the strength of coarse aggregates as shown in fig 3.6. The aggregate crushing value offers a comparative assessment of crushing resistance under a compressive load that is delivered progressively. Low aggregate crushing value aggregate should be chosen in order to produce pavement with a high level of quality. Apparatus used for this test is aggregate crushing apparatus, comprehend cylinder, base plate.

Fig 3.6 Aggregate Crushing Test Apparatus

ii. **Abrasion Test: -**

To determine the abrasion resistance of coarse aggregates, the IS code 2386 Part 4 Abrasion Test was carried out. The abrasion test for aggregate toughness determines abrasion resistance, which includes resistance to crushing, degradation, and disintegration. The percentage of aggregates in the sample that have been worn through from rubbing against steel balls is measured by the Los Angeles Abrasion Value. The Los Angles Abrasion Testing Machine (fig. 3.7), an IS sieve of 1.7 mm, 12 cast iron or steel spheres, each measuring about 48 mm in diameter, and an abrasive charge are the apparatus utilized for this test.

Fig 3.7 Los Angeles Abrasion Machine

iii. **Impact Test: -**

The method outlined in IS code 2386 Part 4 is used to determine the Impact test of coarse aggregates. Engineers evaluate a material's impact resistance and predict how it will function in actual circumstances using the impact test. When they come in contact with flaws, cracks, or notches, many materials degrade rapidly. Impact Testing Apparatus with a metal base and a plane bottom surface that is at least 30 cm in diameter, as illustrated in fig. 3.8, is the apparatus used for this test. It weighs 45 to 60 kg. It is supported by a concrete floor with a minimum thickness of 45 cm that is level and plane.

Fig 3.8 Aggregate Impact Test Apparatus

iv. Specific Gravity and Water Absorption test: -

For the purpose of establishing the specific gravity of coarse aggregates, the Specific Gravity Test was carried out in accordance with IS code 2386 Part 3. The specific gravity test was used to evaluate the strength or quality of the aggregate, whereas the water absorption test determines how much water the coarse and fine aggregates can hold. The main objective of these tests was to gauge the material's strength or quality. The equipment used for this test is an oven with a thermostat that maintains the internal temperature between 100 and 110 °C. a handy-sized perforated container suspended from the balance by thin wire hangers, or a wire basket with a mesh size no larger than 6.3 mm, as depicted in fig. 3.9. two absorbent cloths that measure at least 75 by 45 cm each, a shallow tray.

Fig 3.9 Specific Gravity & Water Absorption Test

v. Fineness Test of Aggregates: -

IS 2386 is a standard method of test for aggregates for concrete, and it includes several tests to determine the fineness of the aggregates. The apparatus for the fineness test of aggregate includes a set of sieves, a sieve shaker, a balance, and a sample of the aggregate. The steps involve arranging the sieves in descending order of aperture size as shown in fig 3.10 (a), placing the sample of the aggregate on the top sieve and shaking the stack of sieves for a specific duration as shown in fig 3.10 (b), weighing the amount of material retained on each sieve, calculating the cumulative weight of the retained material, and expressing it as a percentage of the total sample weight. It is important to ensure that the apparatus is clean and dry for accurate results.

The value of fine aggregate is obtained by adding and subtracting by 100 the total percentage of material retained on each sieve. The fineness modulus increases with aggregate size. Therefore, coarse aggregate has higher fineness modulus than fine aggregate. Sieves used for this test are 20mm, 12.5mm, 10mm, 6.3mm, pan, lid, weighing balance. The Fineness Test sieve is made of No. 325 stainless steel wire cloth and a single-piece brass frame.

(a) IS Standard Sieve **(b)** Sieve Shaker

Fig 3.10 Fineness Test

3.4.3 Test for Slag:

i. Specific gravity Test: -

The specific gravity test for cement (IS 4031:1988 part 11) is used to determine the density of cement particles relative to the density of water. The specific gravity of cement helps in determining the quality and strength of cement. Specific gravity is by definition dimensionless and, given that the units are consistent, is independent of the system of measurements (such as slugsft-3 or kgm-3). The density of a material can be determined using the specific gravity of that substance. The apparatus for determining the specific gravity of cement includes a flask/bottle with a stopper, a weighing balance, and distilled water as shown in fig 3.12. The steps involve weighing the empty flask/bottle, filling it with water up to a specific mark and weighing it again, then filling it with cement and water up to the same mark and weighing it again. The specific gravity of cement is calculated using a formula.

Fig 3.11 Specific Gravity Test of Slag

ii. Initial and Final Settling Time: -

The initial and final settling time of slag in combination with cement (IS 4031) test measures the time taken by a cement paste to reach the initial and final stages of stiffening or setting. The test is carried out using a Vicat apparatus as shown in fig 3.13 and needle to measure the penetration of the needle into the paste at regular intervals. The initial setting time is the time taken by the paste to reach a certain level of stiffness, while the final setting time is the time taken for the paste to become hard and lose its plasticity. This test is important for ensuring that cement-based materials have the right workability and handling characteristics for their intended use. The test is conducted by preparing a cement paste of known consistency, filling it into the Vicat apparatus, and measuring the penetration of the needle at regular intervals until the paste becomes hard and unworkable. The initial and final settling time of cement is usually specified by standards, and varies depending on the type of cement being used.

Fig 3.12 Settling Time Test of Slag

3.5 SELECTION OF WATER-CEMENT RATIO:

We take water-cement ratio = 0.4 (As per Table 5 of IS 456:2000)

Table 3.1 Water cement ratio for different grades (IS 456:2000)

Minimum grade of concrete	Maximum water content
M20	0.55
M25	0.50
M30	0.45
M35	0.40
M40	0.40

We take water-cement ratio = 0.4 (As per Table 5 of IS 456:2000)

3.6 SELECTION OF WATER CONTENT:

20 mm aggregate maximum water content = 186 kg (for 25 to 50 mm slump) According to the codes listed in (IS 456:2000) as calculated on Table 3.14.

Table 3.2 For maximum water content per cubic meter of concrete for nominal maximum size of aggregates

Nominal maximum size of aggregates (mm)	Maximum water content (Kg)
10	208
20	186
40	165

Increasing the water content was necessary because we were aiming for a 25 mm slump. We needed to raise the water content by 3% in order to achieve a 25mm slump increase, and so on

Estimated water content = 186+(3/100) x 186 = 192 Kg

3.7 CONCRETE MIX PROPORTIONS

It is to note that PA can't be replaced by weight of the natural aggregate because of it is light weight and has low specific gravity than conventional aggregate. Therefore, initially weight of natural aggregate for a specific volume say 1m^3 was calculated similar methodology was adopted for PA. After doing close examination, the weight of PA was found to be 1/3rd of natural aggregate of same volume consequently, total weight of PA was taken as the 1/3rd of the weight of the natural aggregate replaced.

Table 3.3 Design mix for Plastic Aggregates used as Normal Aggregate

Sr. No.	MIX ID	CEMENT (Kg/m^3)	Fine Aggregates (Kg/m^3)	Coarse Aggregates (Kg/m^3)	Plastic Aggregate (Kg/m^3)
1	NC	414	666	1282	0
2	PA1	414	666	1239.3	42.7
3	PA2	414	666	1196.6	85.4
4	PA3	414	666	1153.8	128.2
5	PA4	414	666	1111.07	170.93
6	PA5	414	666	1068.34	213.66

Table 3.4 Design mix for Slag used as a Fine Aggregate

Sr. No.	MIX ID	CEMENT (Kg/m^3)	Fine Aggregates (Kg/m^3)	Coarse Aggregates (Kg/m^3)	Slag (Kg/m^3)
1	NC	414	666	1282	0
2	SAFA1	414	599.4	1282	66.6
3	SAFA2	414	532.8	1282	133.2
4	SAFA3	414	466.2	1282	199.8
5	SAFA4	414	399.6	1282	266.4
6	SAFA5	414	333	1282	333
7	SAFA6	414	266.4	1282	399.6
8	SAFA7	414	199.8	1282	466.2

Table 3.5 Design mix for Slag replaced by 10, 20, 30, 40, 50 % used respectively as Cement

Sr. No.	MIX ID	CEMENT (Kg/m^3)	Slag (Kg/m^3)	Coarse Aggregates (Kg/m^3)	Fine Aggregates (Kg/m^3)
1	NC	414	0	1282	666
2	SC1	372.6	41.4	1282	666
3	SC2	331.2	82.8	1282	666
4	SC3	289.8	124.2	1282	666
5	SC4	248.4	165.6	1282	666
6	SC5	207	207	1282	666

3.8 COMPRESSIVE STRENGTH OF CONCRETE

Following 7, 14, and 28 days of curing, a compression testing machine can be used to evaluate the compressive strength of concrete blocks. In order to create the concrete cubes, mix plastic particles measuring 150mm*150mm*150mm were used. The cube mould needs to be thoroughly cleaned and oil-coated inside before casting the cubes. For the curing procedure, ordinary water is used. **Fig. 3.3 (a)** displays cast cubes, whereas **Fig. 3.3 (b)** displays cubes in curing tanks.

(a)

(b)

Fig. 3.13 (a) Cubes before curing, (b) Cubes during curing process

CHAPTER - 4
RESULT ANALYSIS

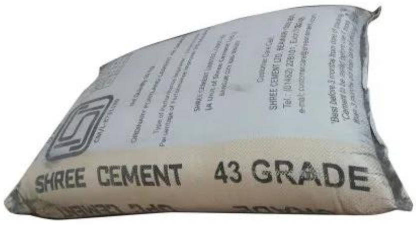
4.1 GENERAL

All the materials required for the present study were cement (OPC-43), Slag (EAFS), natural aggregate and plastic aggregate, in order to check the application of different waste materials in pavement construction IRC44-2017 was followed, and accordingly mix design were prepared which is described in the next section of the present chapter. Besides this, others physical as well as mechanical properties of different materials and concrete mix were performed.

In our study, we aimed to investigate the feasibility of replacing slag and plastic aggregate used as cement/fine aggregate and coarse aggregate. To achieve this, we conducted a series of tests outlined in below tables, our experiment results provided conclusive evidence that natural aggregates and cement can replace with plastic aggregate and slag additionally, we tested the practical application of this finding by casting cubes and beams using waste materials such as plastic aggregate and slag.

4.2 EXPERIMENTAL PROPERTIES

Various experiment on the waste material were conducted and compare accordingly to the values specify by the codes for the values to ensure to be used as the replacement of natural materials like coarse / fine aggregate and cement. The acceptable experiment values according to codes are shown in below tables for different waste materials. All the test were conducted by following the guidelines of IRC/IS codes as shown in below table.



(a)

(b)

(c)

(d)

(e)

Fig 4.1 (a) Cement OPC 43, (b) Slag (c) Natural sand, (d) Natural coarse aggregate and (e) Plastic aggregate

4.2.1 TESTS ON SLAG AND CEMENT

After conducting several tests on the physical properties of slag in accordance with IS codes, it has been determined that slag can serve as a viable substitute for cement. The results of the tests provide evidence of the suitability of slag as a replacement material, opening up possibilities for more sustainable and eco-friendly construction practices

Table 4.1 Slag as cement

Sr. No.	Experiment		Experimental Values		IS Code
			Cement	Slag (30%)	
1	Fineness Test		6.14	4.5	IS 4032-1985
2	Settling Time Test	Initial	50 min	20 min	IS 4031-1985
		Final	500 min	309 min	
3	Consistency Test		32%	35%	IS 4031-1985
4	Specific Gravity Test		3.15	3.17	IS 2720-1985
5	Soundness Test		3mm	4mm	IS 269-2015

4.2.2 TESTS ON FINE AGGREGATE

Following the guidelines set by the IS codes, a series of tests were conducted to evaluate the physical properties of slag, leading to the conclusion that it can effectively replace fine aggregate in various applications

Table 4.2 Slag as Fine Aggregate

Sr. No.	Experiment	Experimental Values		IS Code
		Fine Aggregate	Slag (50%)	
1	Specific gravity Test	2.8	3.17	IS 2720-1985
2	Fineness Test	4.53	4.53	IS 4031-1985

4.2.3 TESTS ON COARSE AGGREGATE

Several physical property tests were carried out on plastic aggregate in accordance with the IS codes, leading to the conclusion that it can be utilized as a viable alternative to coarse aggregate

Table 4.3 Plastic Aggregate as Coarse Aggregate

Sr. No.	Experiment	Experimental Values		IS Code
		Coarse Aggregate	Plastic Aggregate (30%)	
1	Crushing Test	15.6%	0	IS 2386-1963
2	Abrasion Test	18.7%	0	IS 2386-1963
3	Impact Test	5.8%	0	IS 2386-1963
4	Specific Gravity	2.77	0.99	IS 2386-1963
5	Water Absorption test	1%	0.02%	IS 2386-1963
6	Fineness Test	2.77	3.45	IS 2386-1963

4.2.4 FINENESS TEST

(a) For Coarse aggregate

The fineness tests involved replacing coarse aggregate with plastic aggregate and the study of weight distribution of a conventional mix containing both plastic and coarse aggregates were carried out

Table 4.4 Fineness Test of Plastic Aggregates

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	20 mm	10	1.0	1.0	99.0
2	12.5 mm	660	66.0	67.0	33.0
3	10 mm	140	14.0	81.0	19.0
4	6.3 mm	155	15.5	96.5	3.5
5	PAN	35	3.5	100	0
Total		1000		345.5	

Weight of Sample = 1 Kg =1000 gm

Fineness Modulus = [B(Total)/100] = 3.45

Table 4.5 Fineness Test of Conventional Aggregates

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	20 mm	35	3.5	3.5	96.5
2	12.5 mm	746	74.6	78.1	21.9
3	10 mm	180	18.0	96.1	3.9
4	6.3 mm	39	3.9	100	0
5	PAN	0	0	0	0
Total		1000		277.7	

Weight of Sample = 1 Kg =1000 gm

Fineness Modulus = [B(Total)/100] = 2.77

Table 4.6 Fineness Test of (30% Plastic Aggregates + 70% Conventional Aggregates)

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	20 mm	5	0.5	0.5	99.5
2	12.5 mm	651	65.1	65.6	34.4
3	10 mm	224	22.4	88.0	12.0
4	6.3 mm	105	10.5	98.5	1.5
5	PAN	15	1.5	100	0
Total		1000		352.6	

Weight of Sample = 1 Kg =1000 gm

Fineness Modulus = [B(Total)/100] = 3.52

Figure 4.2 displays the size distribution of CA, PA, and PA+CA, providing a visual representation of the relative proportions of each constituent

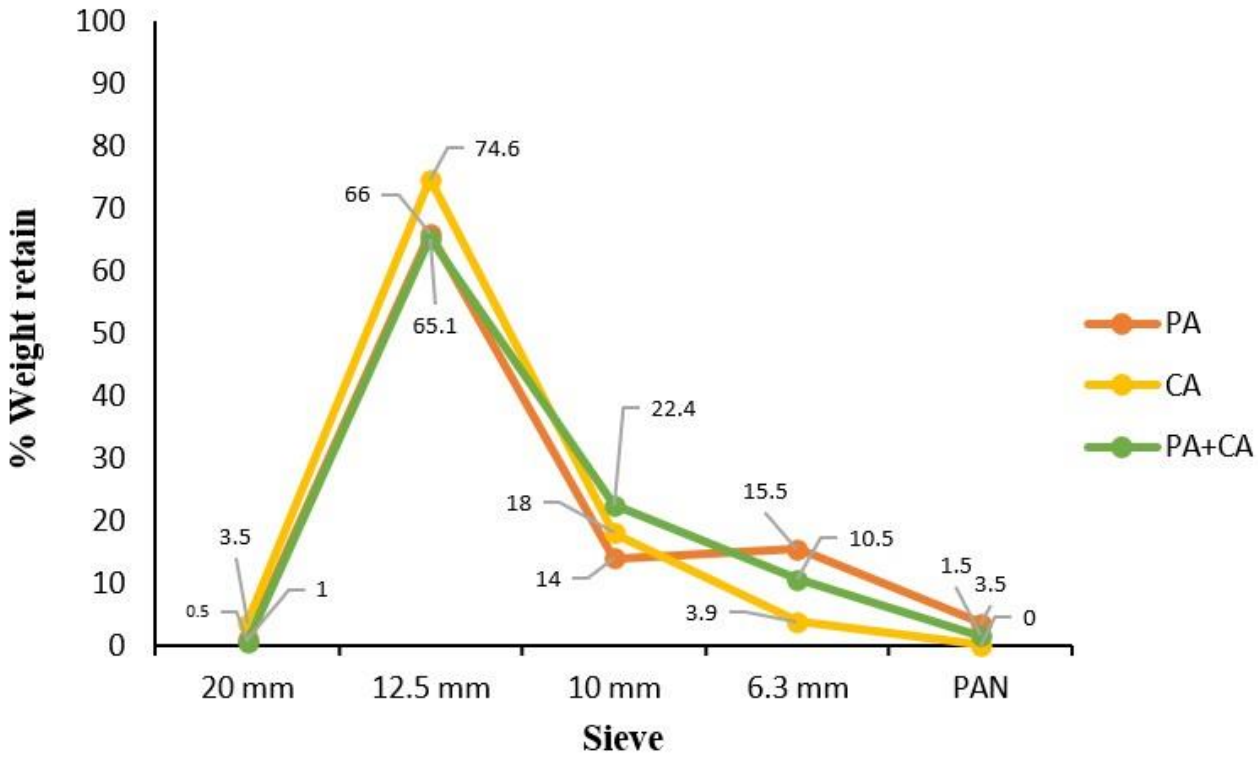


Fig 4.2 Partical size distribution of PA,CA,PA+CA

(b) For Fine aggregate

To assess fineness, fine aggregate was replaced with slag and the weight distribution of a conventional mix containing both slag and sand was analysed

Table 4.7 Fineness Test of Fine Aggregates (Natural Sand)

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	10 mm	0	0	0	100
2	4.75 mm	66	6.6	6.6	93.4
3	2.36 mm	110.5	11.05	17.65	82.35
4	1.18 mm	140	14.0	31.65	68.35
5	600 µm	98	9.8	41.45	58.55
6	300 µm	263	26.3	67.75	32.25
7	150 µm	246	24.6	92.35	7.65
8	90 µm	35.3	3.53	95.88	4.12
9	PAN	41	4.1	99.98	0.02
Total		1000		453.31	

Weight of Sample = 1 Kg =1000 gm

Fineness Modulus = [B(Total)/100] = 4.53

Table 4.8 Fineness Test of Fine Aggregates (50%Natural Sand+50%slag)

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	10 mm	0	0	0	100
2	4.75 mm	38	3.8	3.8	96.2
3	2.36 mm	68	6.8	10.6	89.4
4	1.18 mm	108	10.8	21.4	78.6
5	600 µm	74	7.4	28.8	71.2
6	300 µm	310	31.0	59.8	40.2
7	150 µm	324	32.4	92.2	7.8
8	90 µm	40	4.0	96.2	3.8
9	PAN	38	3.8	100	0
Total		1000		412.8	

Weight of Sample = 1 Kg =1000 gm (500g sand + 500g slag)

Fineness Modulus = [B(Total)/100] = 4.12

Table 4.9 Fineness test of slag as fine aggregates

Sr. No.	Sieve	Weight Retain on Sieve (W) (g)	% Weight retains A=(W/1000) *100	Cumulative % retain (B)	Percentage Passing (100-B)
1	10 mm	0	0	0	100
2	4.75 mm	78.5	7.85	7.85	92.15
3	2.36 mm	169.5	16.95	24.8	75.2
4	1.18 mm	153	15.3	40.1	59.9
5	600 µm	90.5	9.05	49.15	50.85
6	300 µm	125	12.5	61.65	38.35
7	150 µm	186	18.6	80.25	19.75
8	90 µm	94	9.4	89.25	10.35
9	PAN	103.5	10.35	100	0
Total		1000		453.45	

Weight of Sample = 1 Kg =1000 gm

Fineness Modulus = [B(Total)/100] = 4.53

Figure 4.3 illustrates the size distribution of slag, sand, and slag+sand, allowing for a clear visualization of the size ranges present in each component

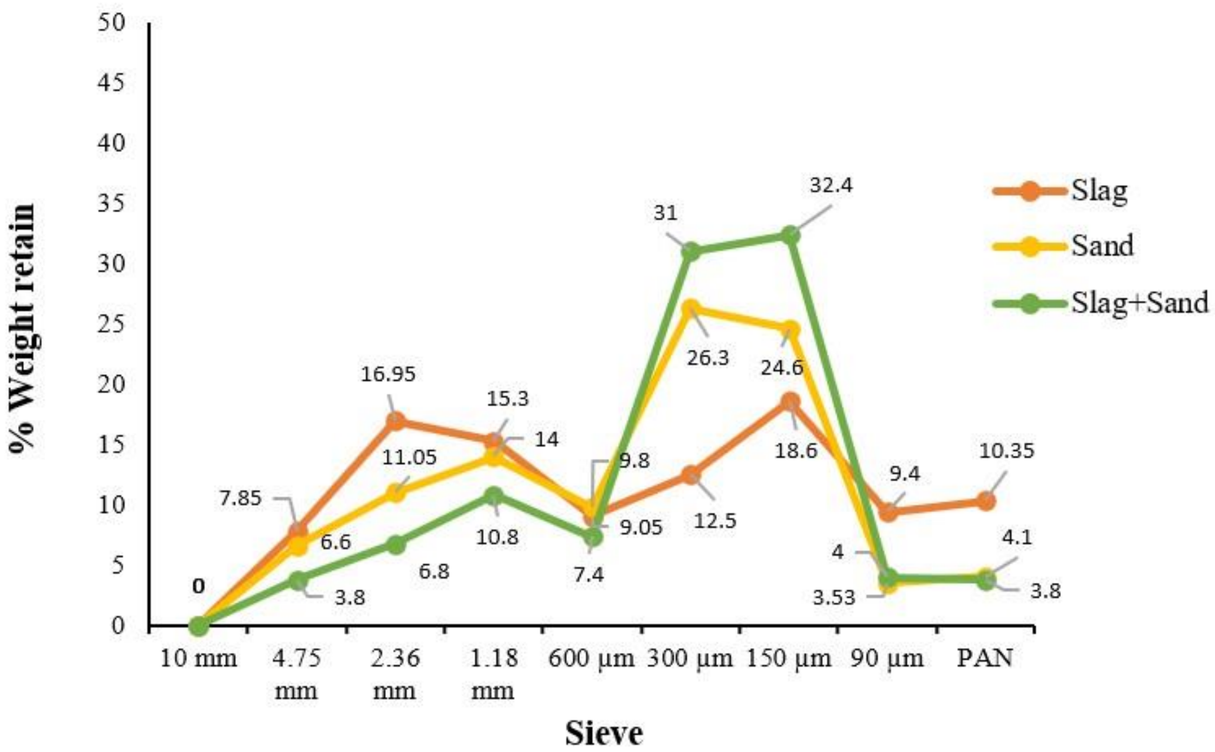


Fig 4.3 Partical size distribution of slag,sand,slag+sand

4.3 MECHANICAL PROPERTIES

After completing the various experiment on waste materials to determine whether we can use them as substitute of natural materials, now we have used those material for casting cubes of different mix proportion to get the impact of different materials on the concrete compressive strength, the values of different waste materials and their impact on the concrete compressive strength are discuss below

Table 4.10 Result for compressive strength of a Normal Concrete

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	NC	8.01	15.07
2	14	NC	7.94	25.13
3	28	NC	7.95	37.5

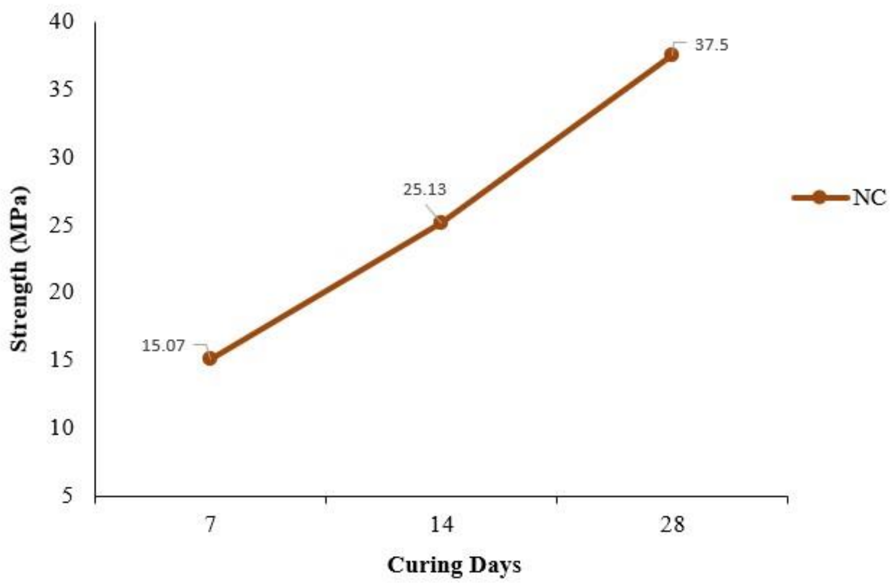


Fig 4.4 Mean Strength of Normal Concrete

(a)

(b)

Fig. 4.5 (a) Cubes before application of load, (b) Cubes after application of load

As shown in Fig 4.2, the compressive strength achieved for normal concrete after 28 days is 37.5 MPa, which is acceptable according to IRC: SP:62-2014. It can be used for construction of roads in rural areas.

4.3.1 Effect of plastic aggregate on compressive strength of concrete

Different mix proportion of plastic aggregate as coarse aggregate replacement from 0% to 50% were made, the maximum compressive strength after 28 days of curing came out to be at 30% replacement of coarse aggregate as plastic aggregate which was recorded about 33.1 MPa

Table 4.11 Result for compressive strength for 30% Plastic Aggregate

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	PA	7.23	10.5
2	14	PA	7.05	24.5
3	28	PA	7.82	33.1

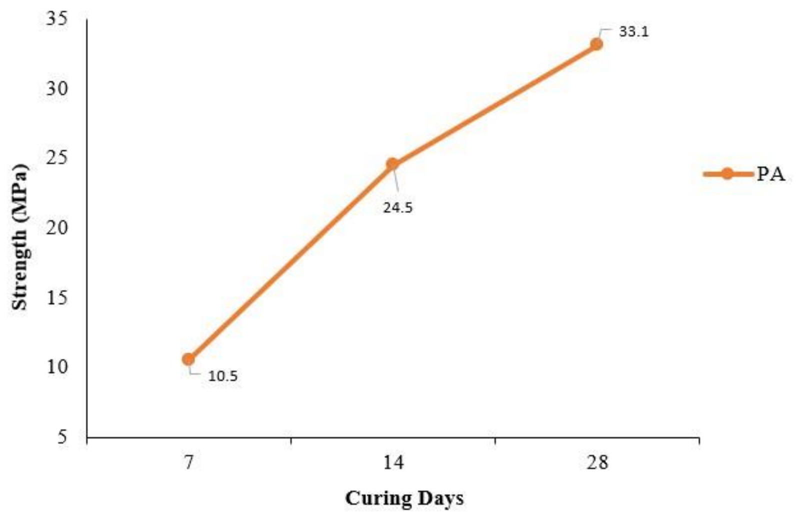


Fig 4.6 Mean Strength of PA Concrete

Fig. 4.7 (a) Cubes before application of load, (b) Cubes after application of load

As shown in Fig 4.3, the compressive strength achieved for PA concrete after 28 days is 33.1 MPa, which is acceptable according to IRC: SP:62-2014. It is very beneficial as plastic waste which is a major concern for environmental sustainability is in abundance can be used as a substitute for coarse aggregate

4.3.2 Effect of slag as cement on compressive strength of concrete

Different mix proportion of slag as cement replacement from 0% to 50% were made, the maximum compressive strength after 28 days of curing came out to be at 30% replacement of coarse aggregate as plastic aggregate which was recorded about 31.4 MPa

Table 4.12 Result for compressive strength for 30% Slag as a Cement

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	SC	7.99	13.8
2	14	SC	7.77	24.6
3	28	SC	8.03	31.4

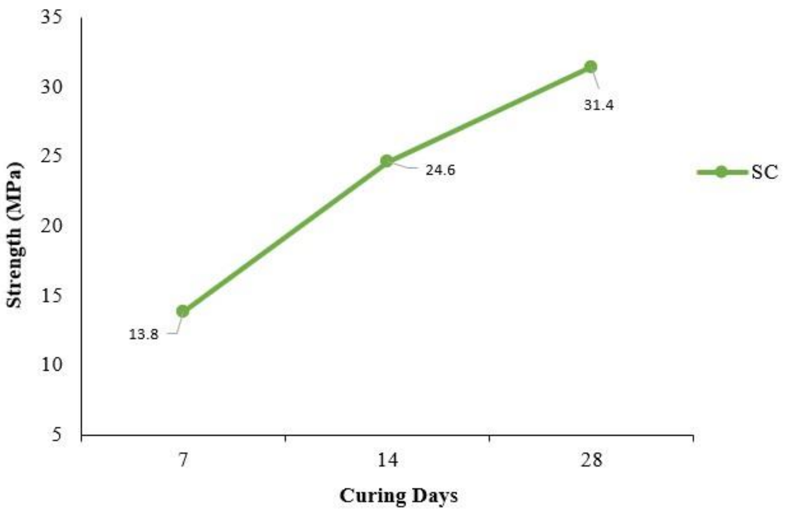


Fig 4.8 Mean Strength of SC Concrete

(a)

(b)

Fig. 4.9 (a) Cubes before application of load, (b) Cubes after application of load

As shown in Fig 4.5, the compressive strength achieved for SC concrete after 28 days is 31.4 MPa, which is acceptable according to IRC:SP:62-2014. Slag is a residue of steel industry which has binding characteristic, as it is in abundance and can be used as a substitute for cement

4.3.3 Effect of slag as fine aggregate on compressive strength of concrete

Different mix proportion of slag as fine aggregate replacement from 0% to 70% were made, the maximum compressive strength after 28 days of curing came out to be at 50% replacement of fine aggregate as slag which was recorded 41.2 MPa

Table 4.13 Result for compressive strength for 50% Slag as a Fine Aggregate

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	SAFA	8.27	25.01
2	14	SAFA	8.14	32.90
3	28	SAFA	8.10	41.2

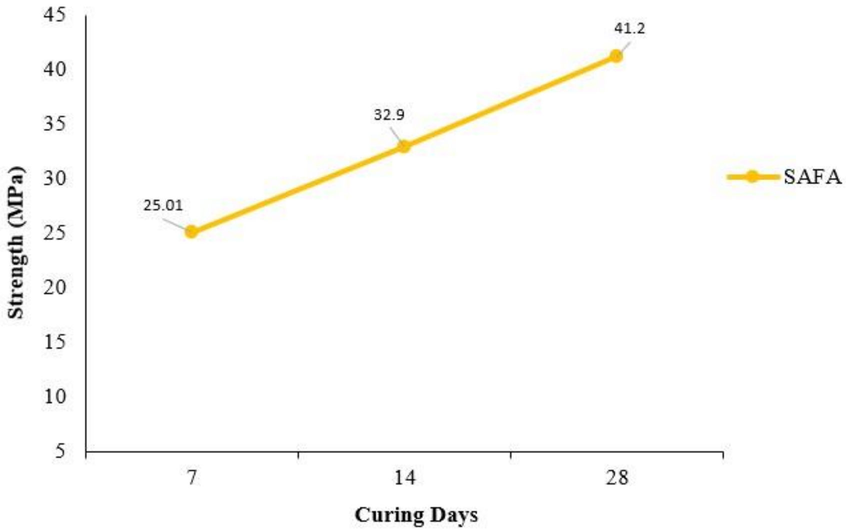


Fig 4.10 Mean Strength of SAFA Concrete

(a)

(b)

Fig. 4.11 (a) Cubes before application of load, (b) Cubes after application of load

As shown in Fig 4.7, the compressive strength achieved for SAFA concrete after 7 days is 25.01 MPa, as it is evident in Graph 4.4, slag as a fine aggregate achieved strength early than other samples. After 28 days, we achieved 41.2 MPa, this can be used for construction of roads in heavy traffic areas like national highways or express highways

4.3.4 Compression of compressive strength of different concrete's

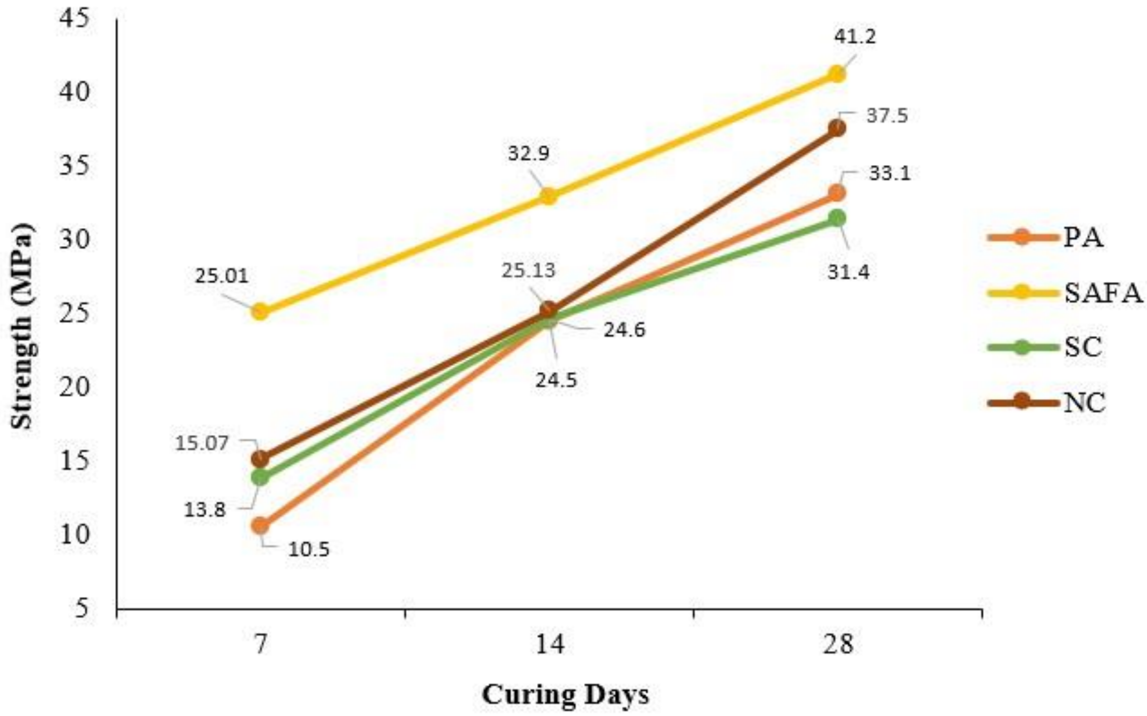


Fig 4.12 Comparison of Compressive Strength of NC, PA, SC and SAFA

As shown in Fig 4.9, the compressive strength of SAFA concrete is greater than other samples, we can conclude that SAFA is better suited for roads in high traffic areas. All the other concrete samples (SC and PA) can be used in low traffic areas as per IRC: SP:62-2014. All these concrete samples are economically cheaper than natural concrete samples as all of these use waste materials are replacing natural aggregate. This makes it environmentally sustainable as well.

4.3.5 Impact of combination of waste materials on compressive strength of concrete

As now we have optimum percentage of individuals of all the waste materials and to increase the compressive strength of concrete, we design the mix of combination of two different mix proportion of wate materials to form a new combination concrete and study the change in the compressive strength of each combination concrete to its individuals' concrete.

Impact of mix (SC and PA) on the compressive strength of concrete

As we have optimum of both SC and PA at 30% respectively the compressive strength of combination concrete is found to be decrease with the addition of both the waste materials in the concrete as compared to their individuals concrete compressive strength.

Table 4.14 Result for compressive strength

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	SC+PA	7.03	9.39
2	14	SC+PA	7.09	13.49
3	28	SC+PA	7.13	26.48

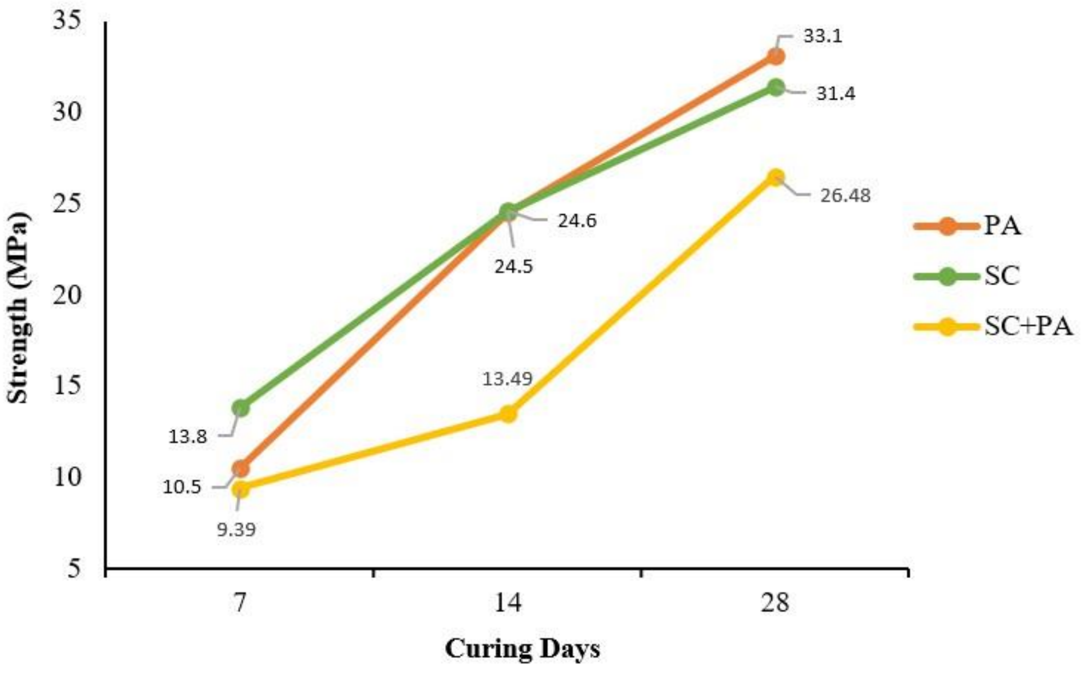


Fig 4.13 comparison on compressive strength of PA, SC and SC+PA

(a)

(b)

Fig. 4.14 (a) Cubes before application of load, (b) Cubes after application of load

Impact of mix (SC and SAFA) on the compressive strength of concrete

As we have optimum of SC, SAFA at 30% and 50% respectively the compressive strength of combination concrete is found to be increase with the addition of both the waste materials in the concrete as compared to SC individuals concrete compressive strength.

Table 4.15 Result for compressive strength

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	SC+SAFA	8.09	24.88
2	14	SC+SAFA	8.17	29.51
3	28	SC+SAFA	7.87	38.4

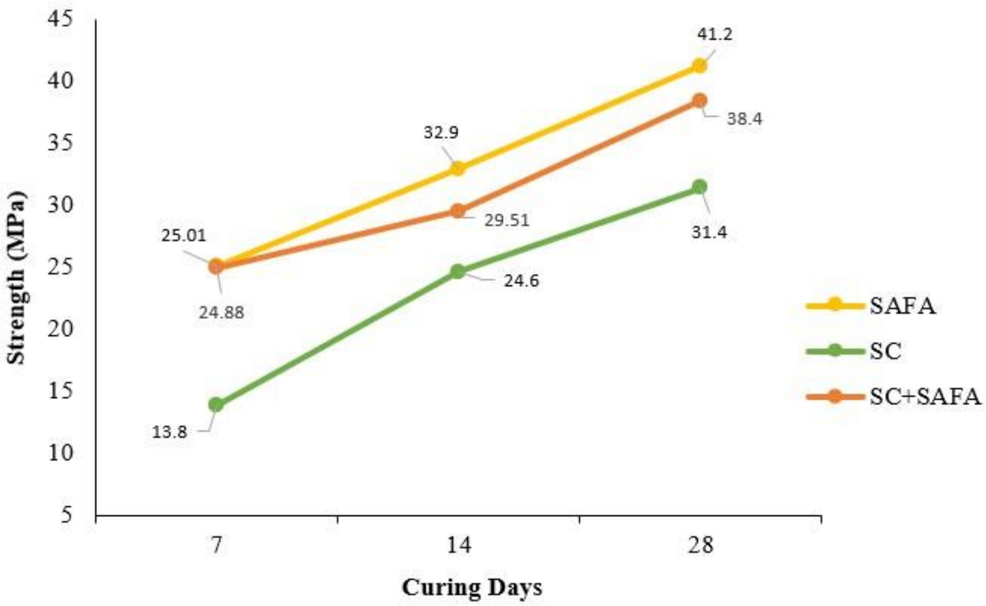


Fig 4.15 comparison on compressive strength of SC, SAFA and SC+SAFA

(a) **(b)**

Fig. 4.16 (a) Cubes before application of load, (b) Cubes after application of load

Impact of mix (PA and SAFA) on the compressive strength of concrete

As we have optimum of both PA, SAFA at 30% and 50% respectively the compressive strength of combination concrete is found to be increase with the addition of both the waste materials in the concrete as compared to PA individuals concrete compressive strength.

Table 4.16 Result for compressive strength

Sr. No.	Days	Type	Weight (Kg)	Strength (MPa)
1	7	PA+SAFA	7.97	19.83
2	14	PA+SAFA	8.17	31.61
3	28	PA+SAFA	7.74	39.7

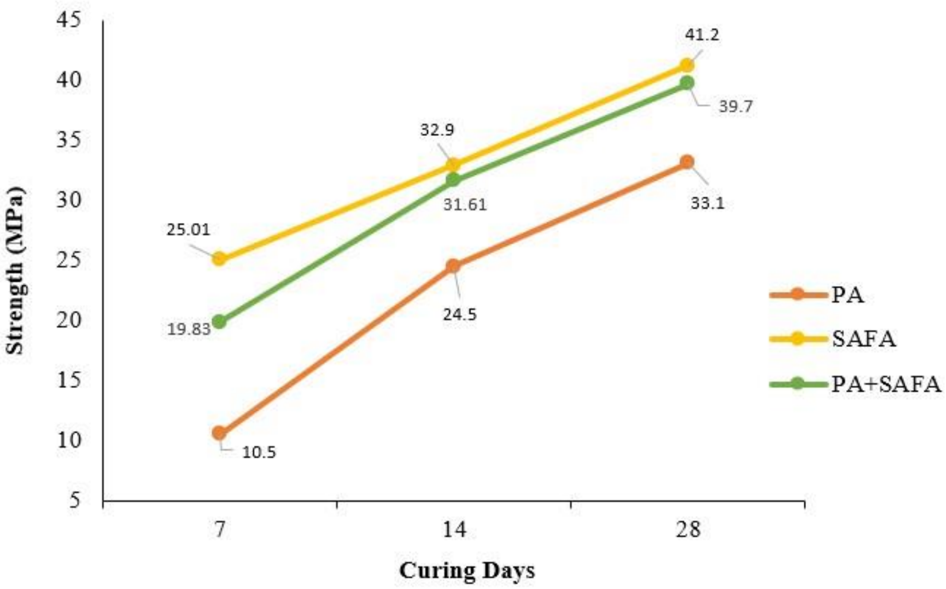


Fig 4.17 comparison on compressive strength of PA, SAFA and PA+SAFA

(a) **(b)**

Fig. 4.18 (a) Cubes before application of load, (b) Cubes after application of load

According to the above results with the addition of slag as fine aggregate we see improvement in compressive strength of concrete as compared to other individuals as well as combination concrete and the combination concrete have well range compressive strength to be used as pavement construction materials for hight to low traffic areas

4.4 Effect of waste materials on flexural strength of concrete

As we have seen changes in compressive strength of concrete with the addition of different waste materials there is also change in flexural strength of concrete as well.

The formula used to determine the flexural strength of concrete mix are

a) If the average length of crack is greater than 13.3 cm, using equation (1)

Strength = (P*L)/(B*D^2) ……...(1)

b) If the average length of crack is between 13.33 to 10 cm, then using equation (2)

Strength = (3*P*a)/(B*D^2) ………(2)

Where **P**= Load

L= Length of beam

B= Breath of beam

D= Depth of beam

a= Average length of crack

Table 4.17 Result for Flexural strength of a Normal Concrete

Sr. No.	Days	Type	Average Length of Crack (cm)	Weight (Kg)	Strength (MPa)
1	7	NC	14.12	10.82	2.75
2	14	NC	15.4	10.72	3.41
3	28	NC	16.33	10.78	4.56

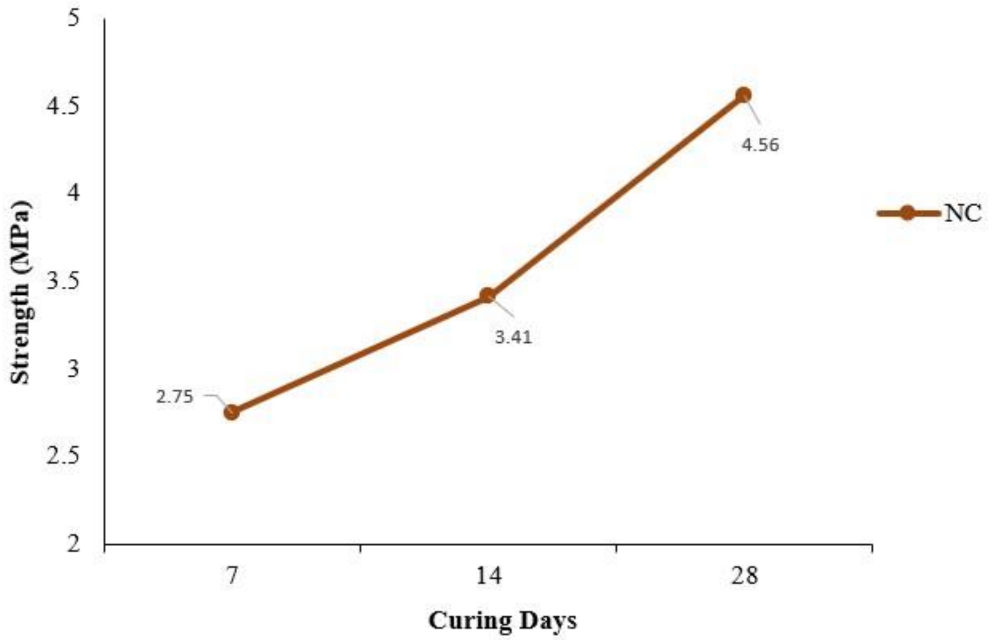
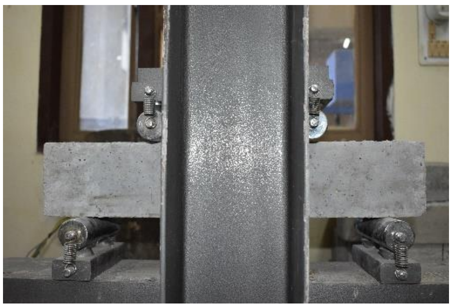


Fig 4.19 Mean Flexural Strength of Normal Concrete

As shown in Fig 4.10, the flexural strength of normal concrete after 28 days is 4.56 MPa which is the optimum strength that should be there in normal concrete.



(a)

(b)

Fig. 4.20 (a) Beam before application of load, (b) Beam after application of load

Effect of plastic aggregate as coarse aggregate on flexural strength of concrete

Table 4.18 Result for Flexural strength for 30% Plastic Aggregate

Sr. No.	Days	Type	Average Length of Crack (cm)	Weight (Kg)	Strength (MPa)
1	7	PA	18.33	10.63	4.75
2	14	PA	16.58	10.78	4.98
3	28	PA	15.7	10.6	5.16

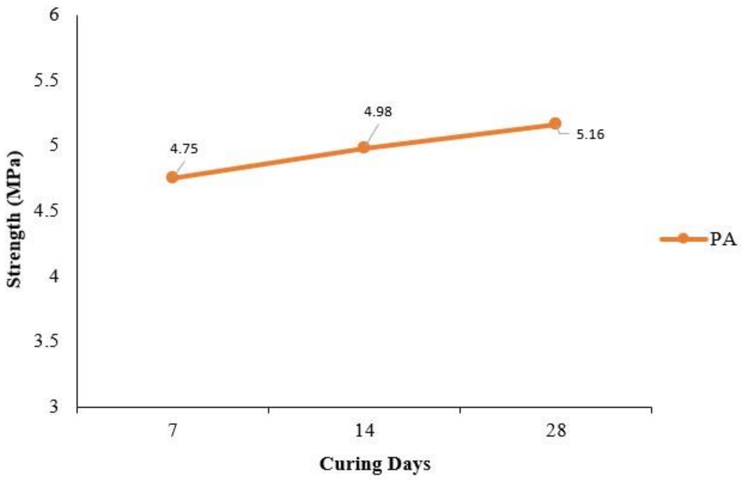
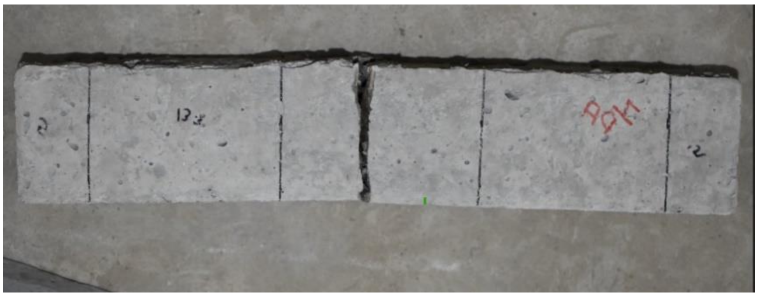


Fig 4.21 Mean Flexural Strength of Plastic Aggregate Concrete

As shown in Fig 4.12, the mean flexural strength of plastic aggregate concrete achieved after 7 days is 4.75 MPa which is higher than the optimum flexural strength. After 28 days, the flexural strength that was achieved was 5.16 MPa which is higher than the optimum flexural strength of normal concrete.

(a)



(b)

Fig. 4.22 (a) Beam before application of load, (b) Beam after application of load

Effect of slag as cement on flexural strength of concrete

Table 4.19 Result for Flexural strength for 30% Slag as a Cement

Sr. No.	Days	Type	Average Length of Crack (cm)	Weight (Kg)	Strength (MPa)
1	7	SC	14.32	11.52	2.4
2	14	SC	14.71	11.54	4.8
3	28	SC	15.64	11.18	5.25

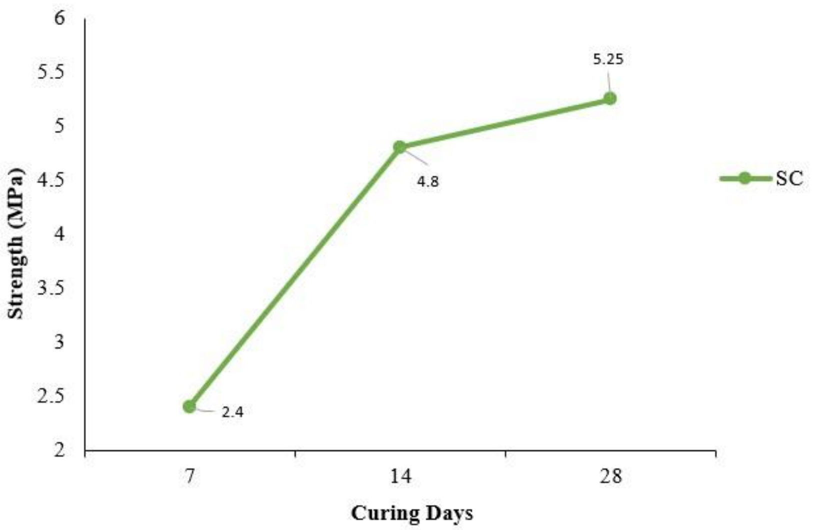


Fig 4.23 Mean Flexural Strength of Slag as Cement Concrete

As shown in Fig 4.14, the mean flexural strength of Slag as Cement concrete achieved after 14 days is 4.8 MPa which is higher than the optimum flexural strength. After 28 days, the flexural strength that was achieved was 5.25 MPa which is higher than the optimum flexural strength of normal concrete.

(a) **(b)**

Fig. 4.24 (a) Beam before application of load, (b) Beam after application of load

Effect of slag as fine aggregate on flexural strength of concrete

Table 4.20 Result for Flexural strength for 50% Slag as a Fine Aggregate

Sr. No.	Days	Type	Average Length of Crack (cm)	Weight (Kg)	Strength (MPa)
1	7	SAFA	13.96	11.97	3.48
2	14	SAFA	15.45	12.09	7.33
3	28	SAFA	16.30	11.89	9.23

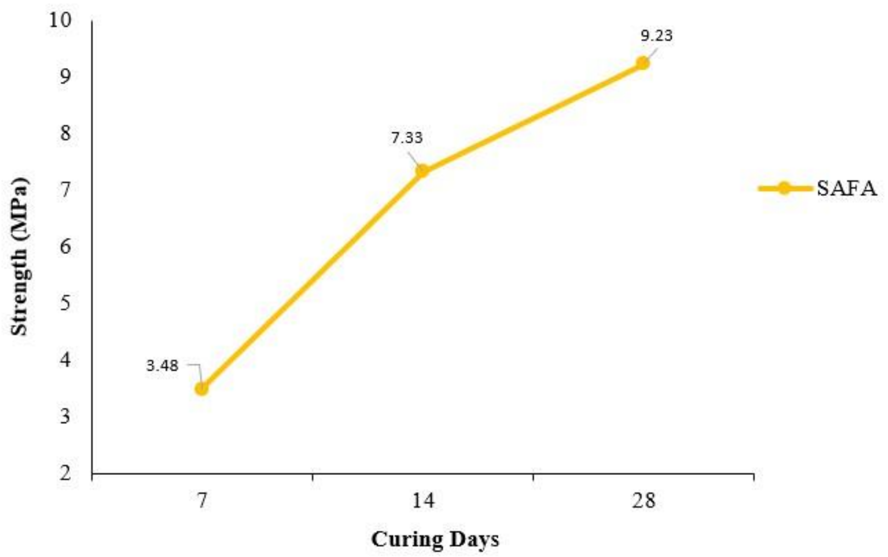


Fig 4.25 Mean Flexural Strength of Slag as Fine Aggregate Concrete

As shown in Fig 4.16, the mean flexural strength of slag as a fine aggregate concrete achieved after 14 days is 7.33 MPa which is higher than the optimum flexural strength. After 28 days, the flexural strength that was achieved was 9.23 MPa which is higher than the optimum flexural strength of normal concrete.

(a) **(b)**

Fig. 4.26 (a) Beam before application of load, (b) Beam after application of load

4.3.4 Compression of flexural strength of different concrete's

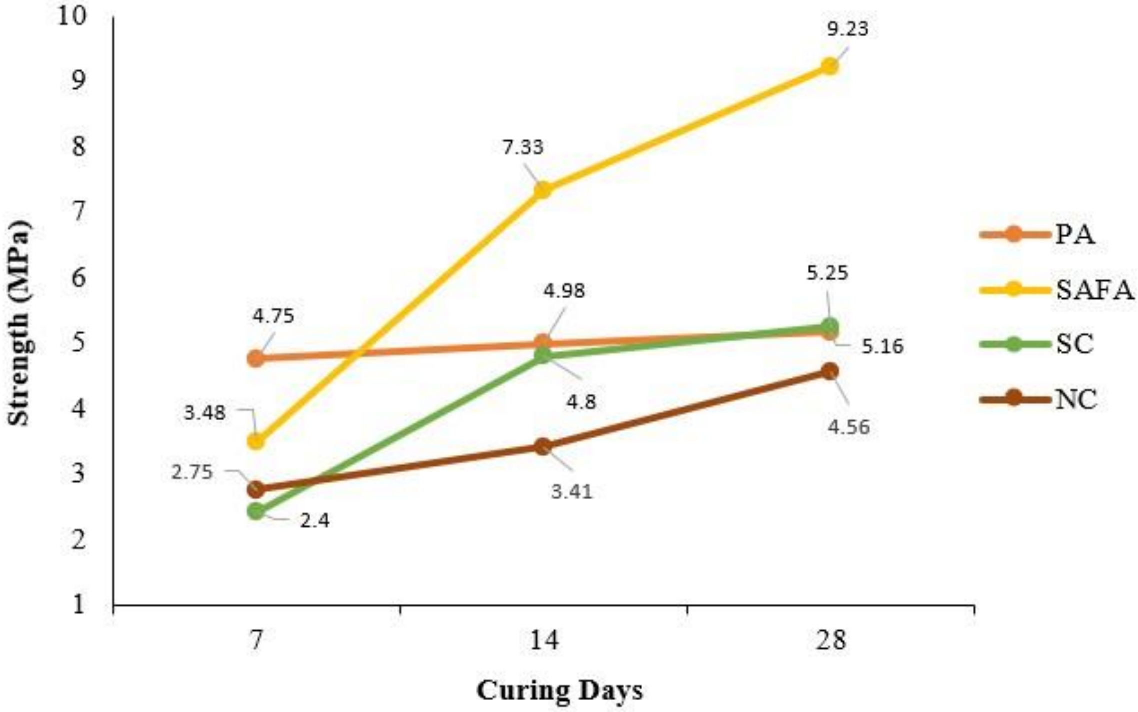


Fig 4.27 Comparison of Flexural Strength of NC, PA, SAFA and SC

As shown in Fig 4.18, the flexural strength of PA concrete is greater than other samples after 7 days of curing, but as curing period increases, the flexural strength of SAFA concrete is considerably higher than other concrete samples. All these concrete samples are economically cheaper than natural concrete samples as all of these use waste materials which are replacing natural aggregate. This makes it environmentally sustainable as well.

CHAPTER – 5

DISCUSSION AND CONCLUSION

5.1 DISCUSSION

In the present study waste materials were used in varying proportion i.e., EAFS (0 to 50%) as the replacement of cement, EAFS (0 to 70%) as replacement of fine aggregate and plastic aggregate (0 to 50%) as replacement of coarse aggregate. On the basis of finding, it was observed that increase of EAFS as replacement of cement will result in decrease of compressive strength and that may be due to the inactive particles of slag which are supposed to be active after 90 days, through EAFS can be used as replacement of cement for up to 30% for low traffic area according to IRC:SP:60-2014 as compressive strength up to 30 MPa can be used for making to pavements for rural areas where as EAFS as replacement of fine aggregate show promising results as compared to the other individuals as well as combination concrete compressive strength. According to the findings of our research, concrete can be made using up to 30 percent plastic aggregates and slag as cement, and up to 50 percent slag as a fine aggregate.

1. The use of plastic aggregate as replacement of coarse aggregate as the compressive strength of concrete using plastic aggregate gives acceptable results according to IRC: SP:62-2014 for low traffic areas (rural areas).
2. Use of plastic aggregate results in light weight concrete which can also be used as a light weight concrete structure.
3. As shown in fig 4.12 slag as a fine aggregate give early strength as compare to other concrete which is to be 25.01 MPa and after the 28 days curing period the compressive strength is found to be 41.2 MPa
4. Steel slag has shown to improve the mechanical properties of concrete, the long-term durability of steel slag as a fine aggregate need further investigation.

5.2 CONCLUSION

The report describes the findings of an experimental investigation that sought to determine whether it would be feasible to produce concrete utilising waste materials, specifically plastic aggregate and slag, in place of natural coarse/fine aggregate and cement. In order to determine the strength of the various concrete mixtures made from these components after 7, 14, and 28 days of curing, the study involved performing various tests on the mixtures and comparing the findings with the reference specimens. The outcomes of the experiment demonstrate that slag and plastic aggregates are both suitable alternatives to cement and natural coarse aggregate, respectively. According to IRC: SP:62-2014, the compressive strength attained for these samples after 28 days is satisfactory which are to be 31.4 MPa and 33.1MPa respectively.

The study also emphasises the environmental advantages of employing waste materials in concrete manufacturing, as plastic waste and slag are both prevalent and provide a serious threat to the sustainability of the environment.in addition, these waste materials are economically less expensive than samples of natural concrete, making them a competitive option for building projects in both low- and high traffic locations. The study's overall findings are encouraging and highlight the potential of waste materials to replace natural resources in the manufacturing of concrete in a sustainable manner, thereby fostering environmental protection and sustainable development. In conclusion, replacing cement/fine aggregates and natural coarse aggregates in concrete with slag and plastic aggregates, respectively, can significantly improve the concrete's mechanical properties while also lowering the industry's environmental impact. Slag and plastic particles in concrete have a lot of possibilities for using sustainable building techniques.

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