

Experimental Investigation on Interlocking concrete blocks made using plastic fibre and ceramic aggregates

Submitted in partial fulfilment of the requirements for the award of
Bachelor of Engineering Degree in
Civil Engineering
by

Ritesh Bhandari (38200703)

Vikrant Mishra (38200040)



**DEPARTMENT OF CIVIL ENGINEERING
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

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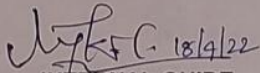
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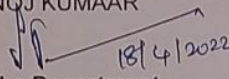
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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **Vikrant Mishra (38200040)** and **Ritesh Bhandari (38200703)** carried out the project entitled "**EXPERIMENTAL INVESTIGATION ON INTERLOCKING CONCRETE BLOCKS USING PLASTIC FIBRE AND CERAMIC AGGREGATES**" under my supervision from December 2021 to April 2022.


INTERNAL GUIDE

Dr. C. MANOJ KUMAAR


Head of the Department

Dr. S. PACKIALAKSHMI

Submitted for Viva-voce Examination held on 2/05/2022

Internal Examiner

External Examiner

DECLARATION

We Vikrant Mishra (38200040) and Ritesh Bhandari (38200703) declare that the Project Report entitled "EXPERIMENTAL INVESTIGATION ON INTERLOCKING CONCRETE BLOCKS USING PLASTIC FIBRE AND CERAMIC AGGREGATES" done by me under the guidance of Mr C . MANOJ KUMAAR is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Civil Engineering.

DATE: 18/04/2022

PLACE: Chennai

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SIGNATURE OF THE CANDIDATES

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ABSTRACT

Because of their advantageous features, Cheap density, excellent strength-to-weight ratio, great durability, simplicity of design and production, and low cost are just a few of the advantages, plastics have become an integral element of our modern lifestyle. During the production, shipping, sale, storage, and usage of all types of ceramic items over time, there is a lot of waste ceramics owing to collisions, ageing, and other issues. According to a literature review, Industrial waste is generated by 30% of the global ceramics sector. However, at the moment, this type of ceramic trash does not have any viable recycling options. The feasibility of combining trash ceramics aggregates and shredded waste plastic to construct concrete blocks that interlock is investigated in this study (ICB). The researchers used a 1:2 concrete mix ratio, with ceramic particles replacing 20% of the sand in the mix. Mixes including plastic (polypropylene) fibres in concrete quantities of 0, 0.5, 1, 1.5, and 2 per cent by weight and a control mix that contained neither ceramic debris nor plastic fibres were constructed. After seven and twenty-eight days of curing treatment, the Compressive strength of interlocking concrete bricks, splitting tensile strength, and water absorption was measured. The microstructure and mineralogy of chosen samples were examined using scanning electron microscopy (SEM). As a result, Compressive and cracking tensile concrete bricks that interlock increased as the plastic fibre %age increased. Microscale measurements also demonstrated good matrix compactness and interparticle interactions. As a result, the study suggests a plastic fibre concentration of 2% for interlocking concrete blocks. Scanning electron microscopy was used to analyse the microstructure and mineralogy of the selected samples (SEM). Microscale studies revealed that the matrix was compact and that interparticle interactions were good. As a result, the study recommends that interlocking concrete blocks have a plastic fibre percentage of 2%.

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LIST OF ABBREVIATIONS

ABBREVIATION USED	WORD
ICB	Interlocking Concrete Blocks
PF	Polypropylene fibre
DC	Developing countries
SEM	Scanning Electron Microscope
OPC	Ordinary Portland Cement
WCA	Waste Ceramic Aggregates
UV	Ultraviolet
SEM	Scanning electron microscope

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CHAPTER 1

INTRODUCTION

1.1 OVERVIEW OF PROJECT

Developing nations (DCs) often have insufficient management of solid waste, with trash pickup rates are inadequate, the principal technique of disposal, dumping, and few options for repurposing goods that are possibly recyclable. Waste products in developing nations, on the other hand, may contribute to a healthy informal economy by providing jobs. Management of waste, notably the disposal of waste plastics, has emerged as a leading environmental and public health problem. In many DCs, recycling infrastructure for these materials is not available, therefore abandon plastic materials have hardly any value, they are destroyed in an inconsistent manner. Local communities suffer greatly as a result of dumping into waterways. Not only are waste plastics ugly, but they also clog urban drainage and sewer systems, producing rapid water infiltrates, as well as offering an ideal fertile environment to mosquito larvae and other ailments conveyed via freshwater.

Polypropylene Fibres have been employed in concrete as a corrosion-resistant, cost-effective reinforcing option. Concrete, being the world's most abundant material created by humans, is the chosen material that cannot be substituted in the so far late twentieth generation for all types of construction for structure. However, as the need for cementitious grows, so does the demand for elements of disposition like a composite of granular material. Ceramic industry and construction must continue to develop in an attempt to face people's requirements and industrial progress. How to appropriately use ceramic waste has become a major matter currently as a result of traditional concrete production of ceramic waste pollution. A major difficulty in the realm of waste management is how to economically employ ceramic waste created by the automotive industries in the building industry's raw material generation.

Reusing granulated ceramic trash in the creation of construction materials not only saves resources and decreases pollution, but it also contributes to society's and nature's long-term sustainability. Blending fully prepared pavement with

ceramic particles leftovers is considered to make eco-sustainable concrete to some extent.

Experiments on concrete made from unconventional resources have revealed that similar characteristics to those of traditional resources could be accomplished.

1.2 ABOUT THE PROJECT

Interlocking concrete blocks are a type of precast artificial stone that can be utilised in a variety of pavement applications. It is made up of coarse and fine aggregates that are bound together by a water-based cement matrix. Because of the shortage and high cost of concrete, the idea of incorporating plastic (Polypropylene) fibre and waste ceramic granules to explore the construction of concrete blocks that interlock evolved. Because the concrete blocks that interlock will be subjected to exposing a lengthy period of time to vehicular stress, they must be long-lasting and strong enough to withstand compression. Polypropylene fibres have recently been researched for strengthening concrete blocks that interlock in order towards improving strength and longevity and fracture reduction.

As a result, the feasibility of combining trash that has been shredded Waste ceramic and polypropylene as fibre aggregates into concrete pavement blocks that interlock, as well as applicability in the use of fibre-reinforced concrete blocks that interlock in the building of pavements, are investigated in this study.

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

The primary goal of a study review would be to supply an overview of the research as well as an in-depth understanding of the research. This lays the groundwork for completing tasks and developing project strategies. The following literature review is about a research study on interlocking concrete blocks employing shredded polypropylene fibres and ceramic particles.

2.2 LITERATURE SURVEY

Paul Awoyera, et al, Water absorption, strength and microscale properties of interlocking concrete blocks made with plastic fibre and ceramic aggregate: The feasibility of employing recycled waste polymer and trash ceramic aggregate (WCA) is investigated in this study to produce concrete blocks that interlock (ICB). After 7 and 28 days of cure, compressive strength, splitting tensile strength, and water absorption was measured. Combinations including polypropylene fibers in %ages of 0, 0.5, 1, 1.5, and 2 by weight of concrete, as well as a comparison mixture without ceramic residue or polypropylene fibres, were prepared. As an outcome, the work suggests incorporating 2 % on average polypropylene fibre in the making of concrete blocks that interlock.

Paul Awoyeraa, et al, Physical, strength, and microscale properties of plastic fibre-reinforced concrete containing fine ceramics particles. : The compressed blocks with 15% PET demonstrated the highest behavior, as their pressure capacity was higher than the others, signifying far less soaking due to the higher degree of absorption.

Johnson Daniel, et al, Experimental study on concrete using waste ceramic as partial replacement of aggregate: Throughout that investigation, the workability of concrete with different blends demonstrated effectiveness, as did a hardened concrete test.

Tulane Rodrigues da Silva, et al, Application of Plastic Wastes in Construction Materials: A Survey of Recent Research By using Idea of Existence Monitoring for Future Insights: Because they are widely available, cheaper, and good for the environment, scrap or polypropylene fibers can be proposed as a useful stabilizer and enhancer in road pavement to optimize combination stability performance.

Rituraj Singh Rathore, et al, Influence of plastic waste on the performance of mortar and concrete: A review: By use of polypropylene as a cement content in cementitious materials enhances the mobility of the slurry due to its low water retention ability.

Juan Pablo Ojeda A meta-analysis on the use of plastic waste as fibers and aggregates in concrete composites. : Designs for strength properties, elasticity modulus, flexural strength, and splitting tensile strength were established using data analysis of thermomechanical and technological parameters.

Safeer Ullah, et al, Characterization of physical & mechanical properties of asphalt concrete containing low- & high-density polyethylene waste as aggregates. The purpose of the study was to evaluate the influence of selectively introducing recycled plastic pellets into asphalt binders and to explore the impact on the various physicommechanical attributes.

Ren Wei, et al, Experimental investigation on bending strength of compacted plastic-concrete. : The goal of this research is to generate stabilized materials for construction that has good mechanical strength than ordinary concrete.

Shannon Kilmartin-Lynch, et al, Preliminary examination of the possibilities of enhancing the structural performance of concrete with polypropylene fibers from

COVID-19 mono face masks. The face masks' fibers managed to decrease the number of crack formations in the concrete, which boosted the general effectiveness.

Fahad Alqahtani, et al, Plastic-based sustainable synthetic aggregate in Green Lightweight concrete. : Strength of concrete, impact modulus, & split tensile all declined as the fraction of polypropylene restored raised, irrespective of the type of substitution (direct or indirect).

Z.C. Steyn, et al, (2020), " Concrete containing waste recycled glass, plastic and rubber as sand replacement": The results of the investigation indicate that the addition of these wastes in concrete influences the properties of concrete. Both the inherent material properties, as well as the physical characteristics of these waste aggregates impact concrete properties.

Ibrahim Almeshal, et al, (2020), " Use of recycled plastic as fine aggregate in cementitious composites: A review": Reuse of plastic waste in the production of concrete or mortar appears as an environmentally friendly solution for getting rid of plastic waste, due to its ecological and economic advantages.

Rabar H, et al, (2020), " Use of recycled plastic in self-compacting concrete: A comprehensive review on fresh and mechanical properties": The empirical relationships among various mechanical properties were also developed. Based on the obtained results from previous studies, recycled plastic self-compacting concrete can be used for structural applications due to its satisfactory fresh and mechanical properties.

Xuemiao Li, et al, (2020), " Functions and impacts of plastic/rubber wastes as eco-friendly aggregate in concrete – A review": Apart from improving ductility of

concrete, one of the most promising characteristics of the plastic/rubber aggregate is the low thermal, acoustical and electrical conductivity and therefore these aggregates are excellent options for producing thermal and sound insulating concrete.

Oluwarotimi Olofinnade, et al, (2020), " Recycling of high impact polystyrene and low-density polyethylene plastic wastes in lightweight based concrete for sustainable construction": Some of the measured parameters of physical properties of the recycled plastic granules are lower compared to the m sand material.

Goutham Sarang, (2019), " Replacement of stabilizers by recycling plastic in asphalt concrete": Waste or recycling plastics can be recommended as an efficient stabilizer and modifier in asphalt concrete to enhance the mixture stability performance, since they are easily available, economic, and moreover have environmental benefits.

Qu Shuying, et al, (2019), " Application of Ceramic Wastes in Concrete": Possibility of ceramic waste use in concrete can be seen from the precedent of the usage of fly ash that is also waste, based on the existing research results of ceramic waste and the experimental research of ceramic waste used in concrete.

P.Pooja, et al, (2019), " Study on Behavior of Concrete with Partial Replacement of Fine Aggregate with Waste Plastics": The plastic wastes that can be obtained in any household, such as milk pouches, water bottles, chocolate wrappers, plastic bags, etc, are collected and used as a replacement for the fine aggregate in concrete.

Enrique del Rey Castillo, et al, (2019), " Light-weight concrete with artificial aggregate manufactured from plastic waste": Inclusion of the manufactured aggregate reduced the density, but compromised the workability of the fresh mix.

Additives were necessary to obtain a workable mix. Inclusion of the manufactured aggregate reduced the compressive strength.

Azad A, et al, (2019), " Some properties of concrete with plastic aggregate derived from shredded PVC sheets": There is a small value of compressive strength and splitting tensile strength loss (not more than 8%) when the coarse aggregate of concrete is replaced by not more than 30% PVC aggregate.

C. Medina, et al, (2019), " Gas permeability in concrete containing recycled ceramic sanitary ware aggregate": The inclusion of recycled sanitary ware ceramic aggregate modified the pore size distribution, raising the volume of capillary pores and lowering the volume of macropores.

Gérard-Philippe Zéhil, et al, (2019), " Feasibility of concrete mixtures containing cross-linked polyethylene waste materials": The compressive and splitting tensile strengths of a concrete drop with increased XLPE content.

Alexander Kumi-Larbi Jnr, et al, (2018), " Recycling waste plastics in developing countries: Use of low-density polyethylene water sachets to form plastic bonded sand blocks": The potential for using this simple technology and the materials it produces to transform LDPE plastic waste management in developing countries is discussed.

Nabajyoti Saikia, et al, (2018), " Use of plastic waste as aggregate in cement mortar and concrete preparation: A review": Several works have been performed or are underway to evaluate the properties of cement-composites containing various types of plastic waste as aggregate, filler or fibre.

Salman Siddique, et al, (2018), " Strength and impact resistance properties of concrete containing fine bone china ceramic aggregate": The compressive strength of concrete increases by increasing the content of fine bone china ceramic aggregate for both standard and long term curing.

Martina Záleská, et al, (2018), " Structural, mechanical and hygrothermal properties of lightweight concrete based on the application of waste plastics": By increasing the amount of plastic aggregates the compressive and flexural strength, as well as the modulus of elasticity, gradually decreased.

CHAPTER 3

AIM AND SCOPE OF THE INVESTIGATION

3.1 AIM

The objectives of the research are as follows:

- To create samples of concrete blocks that interlock along with different compositions of polypropylene fibres.
- To determine the mechanical properties of blocks like compressive strength and split tensile strength.
- To determine the water absorption capacity of the interlocking concrete blocks.
- To determine Microstructural analysis of samples using a Scanning Electron Microscope.
- To Compare the prepared specimen with conventional Interlocking concrete blocks.

3.2 SCOPE

The scope of the project is:

- The ICBs could be useful in countries where the construction materials are scarce and recycling waste plastics, waste ceramic aggregate is the major issue.
- ICBs can replace the conventional ICB due to compressive strength, split tensile strength, and water absorption % being all high.

CHAPTER 4

METHODOLOGY

4.1 MATERIALS

While constructing the concrete blocks that interlock, grade 43 OPC (Ordinary Portland Cement) has been used. To mix these various ingredients of the masonry, clean water was collected through a faucet on the construction site. Ceramic floor and wall tiles were employed in this investigation, which were mostly collected from construction and demolition sites. The crushed waste ceramic, river sand, and plastic fibre are shown in Figure 4.1. In addition, a normalised ternary plot of important OPC oxides and numerous ceramic types is shown. The selected ceramics had a composition that was quite similar. Ceramics in the form of fine aggregates were investigated in this study as a possible contributor to the paste's micro-particle responses.

The water-cement ratio was 0.5 for all amounts of polypropylene applied. Before being employed, the tiles were crushed to granular size (20 mm). As the fine aggregate, river sand was employed. The usage of ceramic as aggregates is advantageous because it is a waste industrial product that aids in product recycling and is also cost-effective. The use of river sand was intended to improve the interlocking concrete block's workability. Plastic cement bags were used to obtain polypropylene fibres. A plastic shredder was used to shred the bags into little pieces. Polypropylene fibres were included in the mix at quantities of 0%, 0.5, 1, 1.5, and 2% by weight of concrete, respectively.



Fig. 4.1: The crushed waste ceramic, river sand, and the polypropylene fibres

4.1.1 Cement

While construction of the concrete blocks that interlock, grade 43 Ordinary Portland Cement (OPC) was employed. OPC 43 Grade Cement is a high-quality cement that is consistently produced from the finest raw materials and is suitable for a wide range of construction projects. It is extremely long-lasting and can be used in a variety of situations, including RCC construction, brick masonry, plastering, pointing, and flooring.

Table 4.1 Physical and chemical test reports of cement

Sl. No.	Test Parameters	Observation	Requirements as per IS 269: 2015
Physical Test			
1.	Normal Consistency	29.2 %	No information was provided.
2.	Setting Time (minutes)		
2.1.	Initial Setting	175	It must not be less than 30 minutes.
2.2.	Final Setting	390	It must not exceed 600 minutes.
3.	Compressive Strength (Average of 3 samples)		
3.1.	3 Days Strength	27.2	Minimum 23 MPa
3.2.	7 Days Strength	38.5	Minimum 33 MPa
3.3.	28 Days Strength	Awaiting	Minimum 43 MPa
4.	Specific Surface Area (Blaine's technique of air permeability)	304	It must be at least 225 M2/kg.
5.	Soundness		
5.1	Method of Le Chatelier (mm)	1.23	It must not exceed 10 mm.
5.2	Autoclave (%)	0.20	Shall not be more than 0.8 mm

Chemical Composition			
6.	Percentage by mass of insoluble residue	2.84	a maximum of 5 %
7.	Magnesia (MgO) as a %age of total mass	2.18	a maximum of 6 %
8.	Total Ignition Loss	3.82	a maximum of 5 %
9.	Sulphur content is computed as sulfuric anhydride (SO ₃) and is expressed as a %age of mass.	1.12	a maximum of 3.5 %
10.	The %age of alumina in comparison to iron oxide.	0.72	At the very least 0.66
11.	Chloride Content	0.001	a maximum of 0.1 %
12.	Alkali content i). Alkalies as Na ₂ O ii). Alkalies as K ₂ O iii). Total alkalies as Na ₂ O equivalent	0.01 <0.01 <0.01	When working with reactive aggregates, it's best to use cement with an alkali concentration of less than 0.6 per cent (expressed as sodium oxide (Na ₂ O) + 0.658 K ₂ O).
13.	The formula $\frac{CaO}{100} - \frac{0.7 SO_3}{100} + \frac{2.8 SiO_2}{100} + \frac{1.2 Al_2O_3}{100} + \frac{0.65 Fe_2O_3}{100}$ calculates the per cent of lime to per cent of Silica, alumina, and iron oxide.	0.68	Not higher than 1.02 per cent Not less than 0.66 per cent

4.1.2 River sand

River sand, also known as Bajri, is a loose, fractured substance made up of very minute fragments of decayed shells, corals, or boulders that occurs naturally. Sand is crucial in the building industry as well as being an important part of the river. It is today one of the most essential building materials, and it is widely utilised all over the world to give building materials like concrete and asphalt bulk, strength, and other qualities.

The inclusion of fine aggregate is meant to increase the concrete blocks that

interlock workability. This sand has a more uniform grain shape and a smoother feel. The river, on the other hand, or natural sand requires very little water.

The trapped moisture between these particles can be used in a variety of concrete applications. The silt content of medium-quality river sand varies between 5 and 20%.

4.1.3 Ceramic aggregates

Ceramic industry and construction must continue to develop in order to address people's demands and economic development. Ceramic waste contamination is a byproduct of conventional concrete manufacture, how to successfully repurpose ceramic waste has been a pressing issue in recent years. A significant challenge in the realm of waste management is how to properly employ ceramic waste created by the ceramic industry in the building industry's raw material manufacturing. Upcycling waste ceramic powder in the manufacturing of building materials provides not only more effective resource use and fewer pollutant emissions but also to the long-term sustainability of society and the environment. Mixing ready-mixed concrete with ceramic powder waste is considered to make environmentally friendly concrete to some extent.

4.1.4 Polypropylene fibres

Polypropylene is a versatile plastic that can be used in injection moulding. Polypropylene lends itself well to fibre applications in addition to traditional plastic applications, giving it an even broader range of applications beyond injection moulding, such as ropes, carpets, furniture, apparel, and the like. Since its invention in the 1950s, polypropylene has grown in popularity.

4.1.4.1 Advantages of polypropylene

The advantages of Polypropylene fibres are:

- It is a reasonably priced substance.
- It seems to have an excellent mechanical property for its Crystallinity form.

- This one has a low coefficient of friction. It can withstand a lot of dampness.
- It is chemically sensitive to a variety of bases and acids.
- It has a high fatigue resistance. It has high impact resistance.
- It has a high electrical resistance and so serves as an excellent electrical insulator.
- It's easier to fix if it gets damaged

4.1.4.2 Disadvantages of polypropylene:

The disadvantages of Polypropylene fibres are:

- Because of its great coefficient of expansion, that can only be used at relatively low temperatures.
- It's sun-sensitive (ultraviolet deterioration). It is sensitive to chlorinated and aromatic solvents.
- It is recognized for being hard to paint due to its poor structure and properties.
- Polypropylene fibres are quite combustible.
- It's unstable to oxidization.

Table 4.2 Physical and chemical properties of polypropylene fibre

Sl. no.	Test parameters	Observation	Requirement as per is codebook
physical properties			
1.	Tenacity	4.8 gm/den	3.5 - 8 gm/den
2.	Density	0.62 gm/c.c	0.81 gm/c.c
3.	Breaking elongation	29%	12-45 %
4.	Flexibility	Excellent	Not specified
5.	Recovering Moisture (MR %)	0%	0%
6.	Reliability	Great	Not specified
7.	Melting point	156 °C	170 °C

8.	Ability to protest heat	Moderate	Moderate
9.	Lustre	Bright to colour	Bright to colour

Sl. No.	Test Parameters	OBSERVATIONS
CHEMICAL PROPERTIES		
1.	Acids	Plastic fibres are unaffected by acid. It has a high capacity to protect against acids.
2.	Basic	Basic has no bearing on basic.
3.	Effect of bleaching	It is capable of preventing the detrimental effects of bleaching at temperatures below 65°C.
4.	Organic solvent	During the action, the organic solvent does not affect the plastic fibre.
5.	Protection ability against light	It loses energy as a result of exposure to sunshine.
6.	Protection ability against mildew	Good.
7.	Protection ability against insects	Insects have no effect on it.
8.	Dyes	Plastic fibres are difficult to colour since they have moisture retention of 0%.

4.2 MIX DESIGN

In a laboratory, Using a weighing balance, concrete mixing was done by weight. It was decided to employ a 1:2 concrete mix ratio. A 20% replacement of crushed ceramic waste for sand was used in this mix ratio. For each concrete mix, discarded at random, varying percentage of polypropylene fibres were introduced. There was also a controlled mix of ICB made in the absence of ceramic waste and polypropylene fibre. Concrete has been batch-mixed by volume. In the steel mould with the dimensions of 200 x 160 x 80, there were a total of 36 samples cast (mm). Table 4.3 illustrates the proportions of interlocking concrete blocks mixed for one

cubic meter, different percentage of polypropylene fibre and a fixed amount of ceramic waste powder were used, as well as the proportions of control interlocking concrete blocks mixed.

Once the concrete blocks that interlock have been cast, blocks were put in a curing tank to cure containing calcareous water for 7 and 28 days to allow them to stiffen as well as strengthen as a result of constant hydration.

Table 4.3 Mix design of samples

SAMPLES	CEMENT (grams)	RIVER SAND (grams)	CERAMIC AGGREGATE (grams)	POLYPRO PYLENE FIBRE (%)	WATER CEMENT RATIO
Control - ICB	1000	2000	0	0	0.5
0% PF - ICB	1000	1600	400	0	0.5
0.5% PF - ICB	1000	1600	400	0.5	0.5
1% PF - ICB	1000	1600	400	1	0.5
1.5% PF - ICB	1000	1600	400	1.5	0.5
2% PF - ICB	1000	1600	400	2	0.5

4.2.1 Identification of Samples

- Control ICB - Interlocking concrete block with no ceramic aggregates and no plastic fibre.
- 0% ICB - Interlocking concrete block with 400 grams ceramic aggregates and no plastic fibre.
- 0.5% ICB - Interlocking concrete block with 400 grams of ceramic aggregates and 15 grams of plastic fibre.
- 1% ICB - Interlocking concrete block with 400 grams of ceramic aggregates and 30 grams of plastic fibre.

- 1.5% ICB - Interlocking concrete block with 400 grams of ceramic aggregates and 45 grams of plastic fibre.
- 2% ICB - Interlocking concrete block with 400 grams of ceramic aggregates and 60 grams of plastic fibre.

Table 4.4 Concrete mix design

S.NO	MATERIALS	QUANTITY
1.	Cement	345 kg/m ³
2.	Fine aggregate	706 kg/m ³
3.	Crushed ceramic Coarse aggregate (20mm)	1086 kg/m ³
4.	water	190 L
5.	Plastic fibre (Polypropylene fibre)	17.25 Kg/m ³

Table 4.5 Total number of samples used

SAMPLES	Water absorption test		Compressive test		Split tensile test		Samples
	7th day	28th day	7th day	28th day	7th day	28th day	
Control - ICB	1	1	1	1	1	1	6
0% PF - ICB	1	1	1	1	1	1	6
0.5% PF - ICB	1	1	1	1	1	1	6
1% PF - ICB	1	1	1	1	1	1	6
1.5% PF - ICB	1	1	1	1	1	1	6

2% PF - ICB	1	1	1	1	1	1	6
Total number of samples							36

4.3 MECHANICAL AND WATER ABSORPTION TEST

4.3.1 *Water absorption test*

Water absorption rate of both the concrete external and internal surfaces is determined by this test. A water absorption test is done to know how much water a block can hold after absorbing it for 24 hours. It is a test to determine the moisture content of the soil as a percentage of its dry weight.

4.3.1.1 *Procedure of test*

The following steps are the procedure for the water absorption test:

- Prepare the samples with various polypropylene fibre and ceramic aggregate compositions.
- Dry the specimen at 105°C to 115°C in a vented oven until it reaches a fairly constant bulk. Before immersing each sample in water, weigh it and record the readings (M1).
- Completely dried specimens should be immersed in water for 24 hours at a temperature of 27±2°C.
- After 24 hours, collect the samples and brush away any excess water on the ICB's surface. Weigh and record the results once more (M2).
- After 24 hours of exploration in the ice stream, water absorption is calculated using the analytical equation $W = \left(\frac{M2-M1}{M1} \times 100 \right)$.

Table 4.6 Readings of water absorption test

SAMPLES	7th-day		28th-day	
	Before	After	Before	After
Control - ICB	4.411 kg	4.521 kg	4.491 kg	4.586 kg
0% PF - ICB	4.413 kg	4.644 kg	4.496 kg	4.698 kg
0.5% PF - ICB	4.428 kg	4.544 kg	4.498 kg	4.602 kg
1% PF - ICB	4.447 kg	4.546 kg	4.512 kg	4.599 kg
1.5% PF - ICB	4.463 kg	4.544 kg	4.521 kg	4.591 kg
2% PF - ICB	4.478 kg	4.541 kg	4.532 kg	4.595 kg





Fig 4.2: Water Absorption Test of Concrete blocks that interlock

4.3.2 Compressive strength test

Test method analyses how a material responds whenever pressed or crushed by identifying key elements that control specimen behavior under stress conditions.

The compressive strength test shows the maximum compressive force that a material can tolerate before breaking. The test component, which is generally in the form of a cube, is compressed between the plates of a load while continuous pressure is applied.

4.3.2.1 Procedure for compression test

The following steps are the procedure for the compression test:

- Put the sample horizontally and also facing upwards in between plates of the machine.
- Axial load is applied at a constant speed of 14 N/mm² per minute until the block breaks, then record the readings of load at which it breaks.
- The load at which the sample or block breaks and due to which there is

no more increase in the gauge is known as the load at failure.

- The formula for calculating ICB's compressive strength is:

Comprehensive strength = Load at which block break / Average area of ICB

Table 4.7 Readings of compression test

SAMPLES	7th day (KN)	28th day (KN)
Control - ICB	400	450
0% PF - ICB	448	600
0.5% PF - ICB	455	640
1% PF - ICB	483	700
1.5% PF - ICB	493	782
2% PF - ICB	494	784



Fig 4.3: Compression test on interlocking concrete blocks

4.3.3 Split tensile strength test

To determine the tensile strength of hardened concrete, the splitting tensile strength test is utilized. It's the maximum force on the tension face of an unreinforced concrete beam or slab at the point of failure in bending. Tensile strength for concrete specimens is defined as the tensile stresses induced by the application of a compressive load at which the concrete specimen may break.

4.3.3.1 Procedure for split tensile strength test

The following steps are the procedure for the split tensile strength test:

- After curing, wipe the liquid off the specimen's body.
- To assure that the two ends of the sample are in the same axial plane, draw completely opposite lines on both ends with a marker.
- Dimensions of the sample should be noted.
- The sample was placed on the lower plate's plywood strip.
- Match the ends of the sample such that the vertically and centered lines are parallel towards the bottom plate.
- Lower the upper plate until it touches the plywood strip, then set the other plywood strip on top of the specimen.
- Continuously apply load without causing shock. Put the breaking load on paper (P).

Table 4.8 Readings of split tensile strength test

SAMPLES	7th day (KN)	28th day (KN)
Control - ICB	60.8	66.7
0% PF - ICB	63.1	73.6
0.5% PF - ICB	66.5	86.4

1% PF - ICB	68.9	90.4
1.5% PF - ICB	75.6	98.7
2% PF - ICB	75.4	98.9



Fig 4.4: Tensile splitting test on interlocking concrete blocks

4.4 SCANNING ELECTRON MICROSCOPE (SEM) TEST

It is a microscopy technique that captures photos via scanning the face of a specimen with a directed sea of electrons. When electrons contact elements in a specimen, they introduce a range of pulses that convey information about the sample structure and composition of the material. Crums from the examined samples were used for microstructural studies after the compressive and split tensile strength tests were completed, in order to evaluate their interior structure and mineral content. On the 28-day-cured sample, scanning electron microscopy was performed. . The control mix ICB, the mix with no polypropylene fibre, the mix with 1.5 % plastic fibre, and then mix with 2 % plastic fibre were the only samples used in these testing.

Findings of the microscopy technique revealed microstructure features at various magnifications (2.5k, 5k, 7.5k, 10k).



(a). Normal - ICB's powder



(b). 0% Polypropylene fibre - ICB's powder



(c). 1.5% PF - ICB powder



(d). 2% PF - ICB powder

Fig 4.5: Samples for scanning electron microscope test

CHAPTER 5

RESULTS AND DISCUSSION

5.1 RESULTS OF WATER ABSORPTION TEST

These are the results for water absorption after conducting the test:

After 7 and 28 days of cure, the interlocking concrete blocks' water absorption capability was tested. Table 9 shows the results of the tests conducted at 7 and 28 days after cure.

The water absorption of the specimen with 0 % polypropylene fibre and the specimen with 2 % polypropylene fibre was 73.23 % lower after 7 days of curing. The control mix also absorbed 52.39 % less water than the specimen with 0% polypropylene fibre, suggesting that a sand replacement rate of 0% in ICBs results in reduced water retention than a sand-to-ceramic trash exchange of 20% as shown in Table 5.1 and Fig 5.1.

Over 28 days of cure, the samples with polypropylene fibre retained less moisture than the samples without. The specimen adding 0.5 % polypropylene fibre received the least water among the 20 % partial substitution of specimens. In between the two specimens with 0% polypropylene fibre and the specimen with 0.5 % polypropylene fibre, water absorption decreased by 59.07 %. The normal mix absorbed 66.71 % less water than the specimen with 0% polypropylene fibre, demonstrating that a block with 0% plastic fibre content absorb more water than that blocks containing plastic fibre at varying proportions as shown in table 5.1 and Fig 5.1.

As can be observed from the graph, the interlocking blocks with 0.5 % polypropylene fibre had the least water absorption among the 20 % partial replacement of sand. This decrease in water absorption can be attributed to the polypropylene fibres that hold the concrete aggregate together and minimize micropores within the concrete. Broken ceramic materials have a greater moisture content, which aids the composite to perform much better altogether when it comes to the role of ceramics on the water absorption capabilities of the combination

Table 5.1 Results on water absorption test

SAMPLES	7th Day(%)	28th day(%)
CONTROL-ICB	2.49	2.11
0% PF-ICB	5.23	4.49
0.5% PF-ICB	2.61	2.31
1% PF-ICB	2.22	1.92
1.5% PF-ICB	1.81	1.54
2% PF-ICB	1.40	1.39

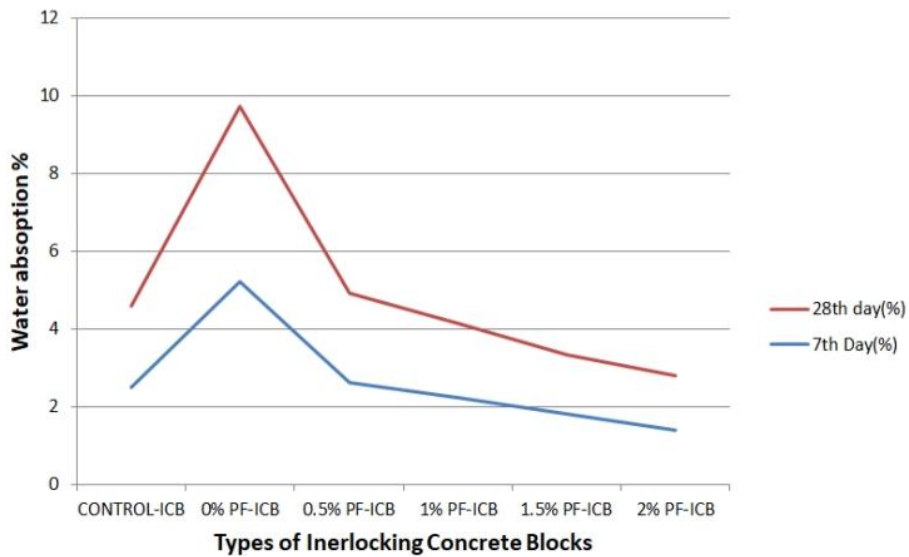


Fig 5.1: Graphical representation of Water absorption test for 7-day and 28-day

5.2 RESULTS OF COMPRESSION TEST

These are the results of the Compression test after conducting the test:

The compressive strength test findings for several curing days are also shown in Table 5.2. According to observations, the concrete blocks that interlock's compressive strength improved as the amount of polypropylene fibre rose throughout the various curing days.

The specimens with the lowest compressive strengths were those that had been curing for 7 days, whereas the samples with the highest compressive strengths were those that had been curing for 28 days. On two separate curing days, the samples with 2% polypropylene compressive strength of the fibre content were the greatest, the sample from 28 days had the maximum compressive strength as shown in Fig 5.2.

These results reveal that samples with 0% polypropylene fibres had greater compressive strength than the control mix. This demonstrates that samples with 20% sand replacement had higher compressive strength than those with 0% sand replacement with ceramic aggregates.

Between the samples 2 % PF and 0 % PF, there was a 9.29 % increase in compressive strength after 7 days of curing. In addition, the samples containing 2% PF had a compressive strength of 18.9% greater than the control mix. The control mix exhibited a compressive strength of 10.68 % lower than the PF-free samples. Table 10 and Figure 6 provide the above information.

The compressive strength of samples containing 2 % PF and 0 % PF increased by 23.25 % after 28 days of curing. When comparing samples containing 2 % PF to the control mix, it can be shown that there was a 42.46 % difference. The compressive strength of the control mix was 25.02 % lower than that of the Plastic fibre free samples. Table 5.2 and Figure 5.2 provide the above information.

We may infer that the samples with a 20% ceramic aggregate substitution had a better compressive strength than the samples with no sand replacement, i.e. the control mix.

The improvement in strength with raising the number of polypropylene fibres applied can be ascribed to the polypropylene fibres keeping the concrete matrix together, thereby improving the impact strength to load of the interlocking blocks.

Table 5.2 Results of compression test and split tensile test

SAMPLES	Compressive Strength		Split Tensile Strength	
	7th day	28th day	7th day	28th day
CONTROL ICB	14.54	16.36	2.42	2.65
0% PF - ICB	16.29	21.81	2.51	2.92
0.5% PF - ICB	16.54	23.27	2.64	3.43
1% PF - ICB	17.56	25.45	2.74	3.59
1.5% PF - ICB	17.92	28.43	3.01	3.92
2% PF - ICB	17.96	28.41	3.01	3.93

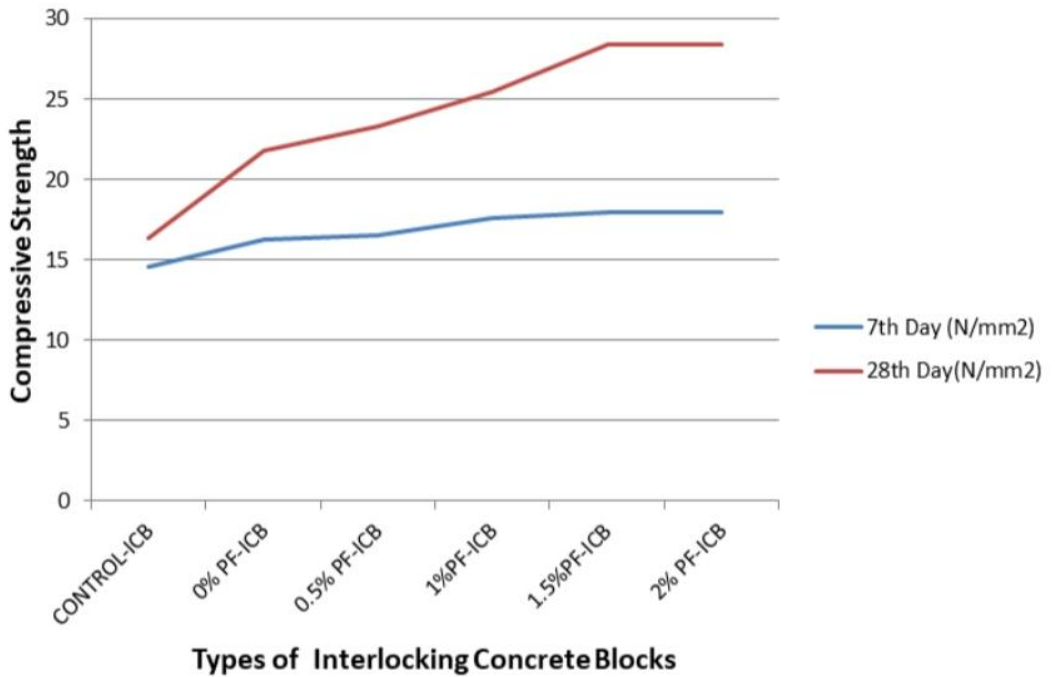


Fig 5.2: Compressive strength test results for 7 days and 28 days of cure.

5.3 RESULTS OF SPLIT TENSILE TEST

These are the results for split tensile after conducting the test:

After 7 and 28 days of cure, the split tensile strength of the casted concrete blocks that interlock was evaluated. After the split tensile strength test, the PF has been seen keeping the concrete matrix together. The split tensile strength of the concrete blocks that interlock is shown in Fig. 5.3.

Figure 5.3 depicts the relationship between the 28th-day split tensile strength and the 7th-day compressive strength. As the proportion of PF in the blocks grew for the different curing days, the split tensile strength of the interlocking concrete block increased, as shown in Fig. 5.3. The samples with the lowest split tensile strength were those that had been curing for 7 days, while those with the highest split tensile strength were those that had been curing for 28 days.

There was a 16.61 % increase in split tensile strength between samples containing 2 % PF and samples containing 0 % PF after 7 days of curing. In addition, the sample with 2% PF had a 19.60 % Split strength is greater in this blend than in the control mix. We can also see from Table 5.2 and Fig 5.3 that the control mix's splitting strength was 3.58 % lower than the sample with 0% PF. As a consequence, the sample with a 20% substitution of ceramic aggregates for sand has greater tensile strength than the sample with a 0% substitution of sand.

There is a 25.69 % increase in tensile strength between samples containing 2 % PF and samples containing 0 % PF after 28k days of curing. In addition, between samples of the control mix and those with 2% PF, there was a 32.56 % increase in split tensile strength. The control mix's tensile strength was 9.24 % lower than the specimen with 0% PF, showing that a sample with a 20% substitute for sand with ceramic aggregates had greater tensile strength than a sample with a 0% substitute for sand.

As shown in Table 5.2 and Fig 5.3, the rise in split tensile strength with a rise in the % of polypropylene fibres may be ascribed to the polypropylene fibres keeping the concrete matrix together and enhancing the resilience to the load of the concrete blocks that interlock.

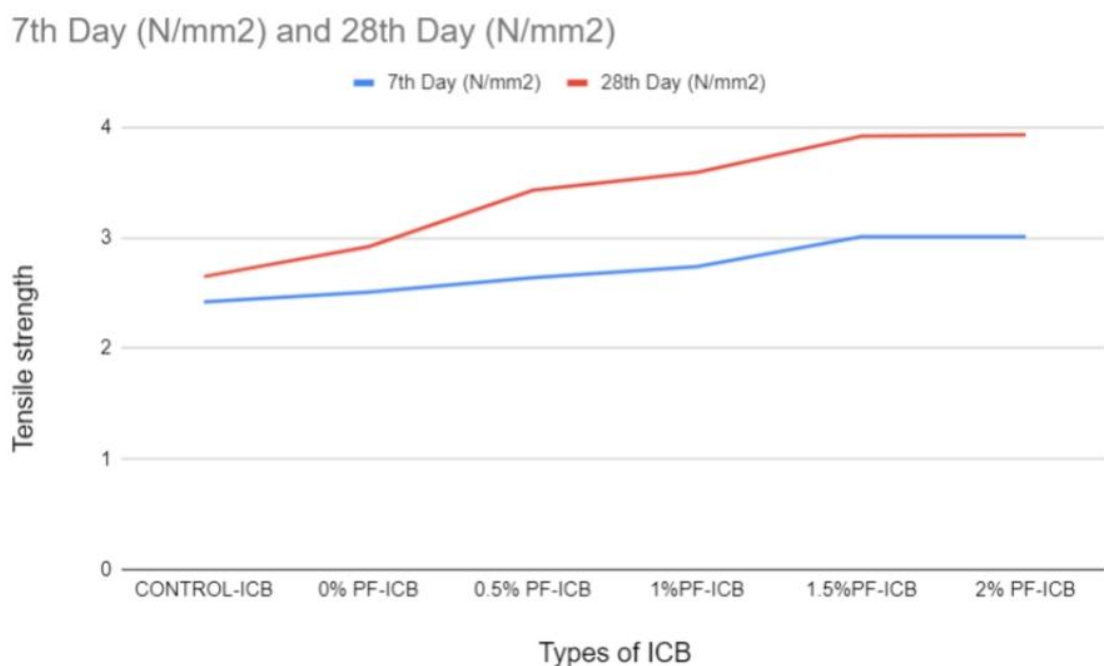


Fig 5.3: Graphical representation of Tensile splitting test during a 7-day curing period, followed by a 28-day curing period.

5.4 RESULTS OF SCANNING ELECTRON MICROSCOPE TEST

These are the results of scanning electron microscope after conducting the test:

Figures 5.4, 5.5, 5.6, and 5.7 demonstrate the results obtained at various magnifications. When the cement was soaked with the waste ceramic, it was found that angled mortar particles were accompanied by projecting calcium silicate hydrate (C-S-H) fibres, similar to the C-S-H beginning predicted in conventional cement. Spontaneously arranged portlandite ($\text{Ca}(\text{OH})_2$) crystals and prismatic crystalline crystals were widely circulated under the influence of 1.5 % polypropylene fibre-ICB's and 2 % polypropylene fibre-ICBs.

The structural phase is constituted of needle-shaped crystalline grains and small tooth outward manifestations of C-S-Hs enclosing cement particles. Inside the 1.5 % polypropylene fibre-ICB's and 2 % polypropylene fibre-ICBs', waste ceramic

grains were reported to be embedded with undifferentiated (in respect of C-S-H) stacked CH hydration products.

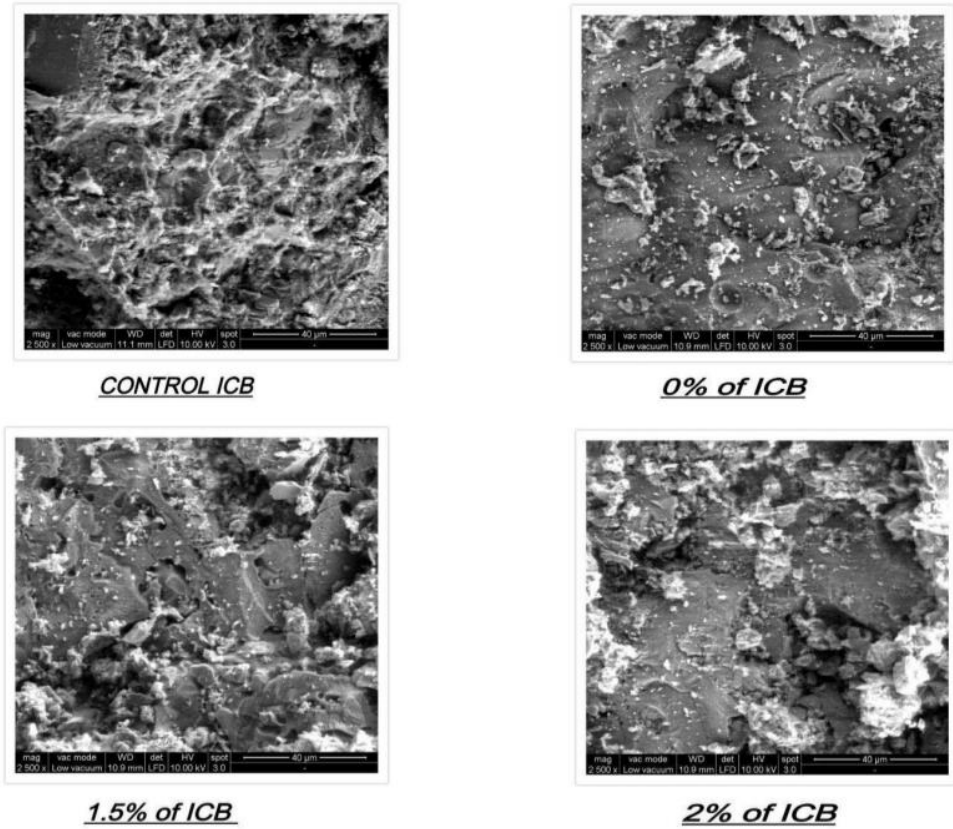


Fig 5.4: Results on 2.5k magnification of the SEM

As we closely observe from figure 5.4, the hydration products form around the aggregates and it was found that angled mortar particles were accompanied by projecting calcium silicate hydrate (C-S-H) fibres in 1.5%-ICB and 2%-ICB. Control ICB showed a very blurred formation of calcium silicate hydrate (C-S-H) fibres and portlandite (Ca(OH)_2) crystals and prismatic crystalline crystals which results in more water absorption, weak compressive and tensile stress carrying capacity.

If we compare the 0% PF-ICB and the 2% PF-ICB, the formation of portlandite (Ca(OH)_2) crystals and prismatic crystalline crystals is more in 2% PF-ICB, also the size of calcium silicate hydrate (C-S-H) fibres is bigger in the 2% PF-ICB and small in 0% PF-ICB, which leads to the result that the 2% PF-ICB have

more compressive and tensile stress carrying capacity and also absorbs less water due to fewer pores available in them. Comparing the 1.5% PF-ICB and 2% PF-ICB, the size of the voids present in them differs slightly and do also the compressive strength test and split tensile strength test.

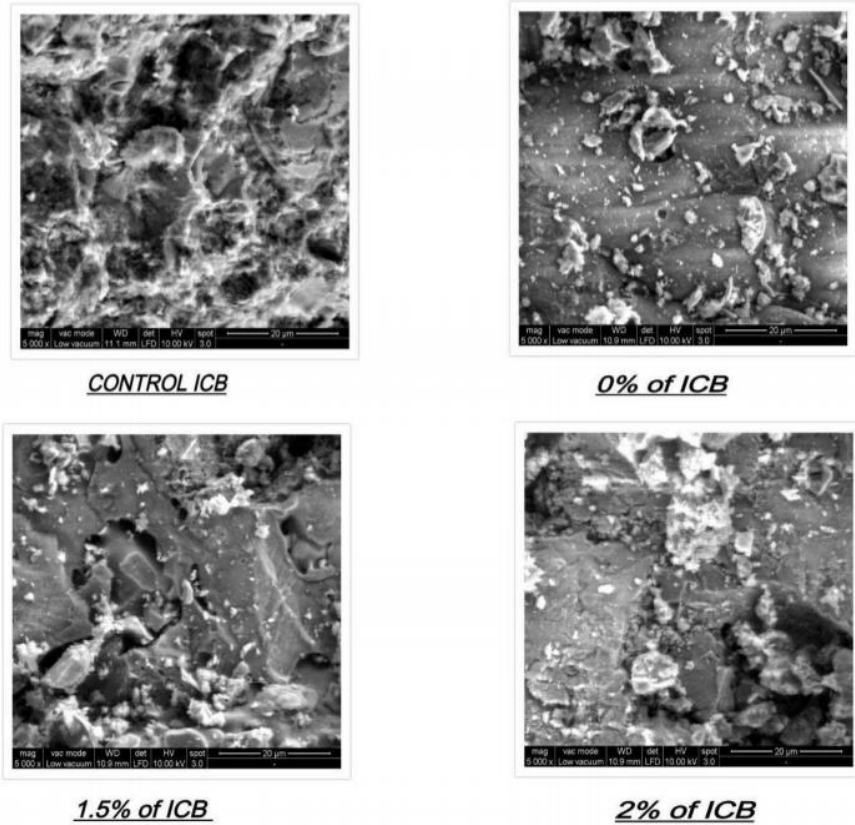
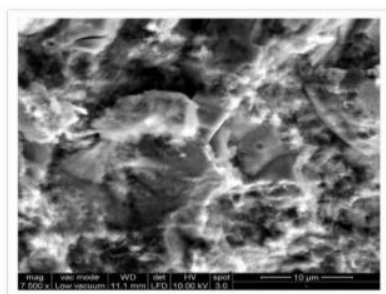
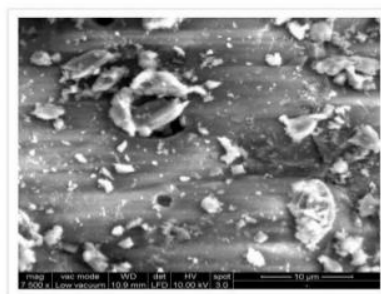


Fig 5.5: Results on 5k magnification of the SEM

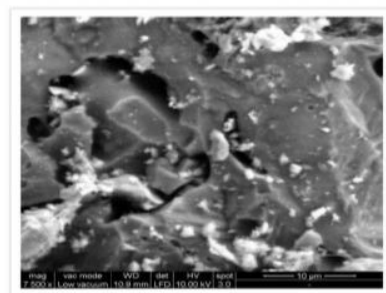
From fig 5.5, which was at 5k magnification resembles the blurred appearance of the calcium silicate hydrate (C-S-H) in the control ICB. The size of hydration products like portlandite (Ca(OH)_2) crystals and prismatic crystalline crystals is seen larger in 2% PF-ICB followed by 1.5% PF-ICB and then 0% PF-ICB. Resulting in a high water absorption test, compression test, and split tensile test in 2% PF-ICB and then in 1.5% PF-ICB followed by 0% PF-ICB and control mix ICB. Control ICB has the lowest of the strengths and water absorption test among the others. The pores or voids can be seen more in 1.5% PF-ICB and 0% PF-ICB and less in 2% PF-ICB.



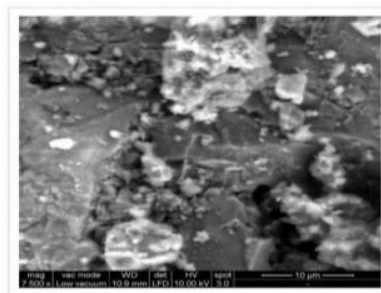
CONTROL ICB



0% of ICB

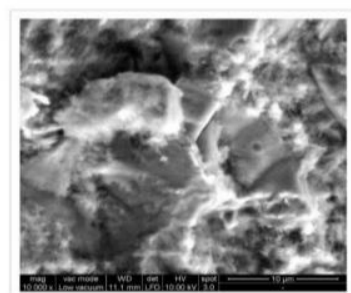


1.5% of ICB

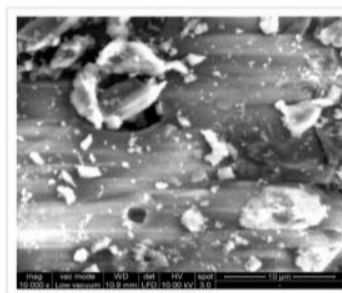


2% of ICB

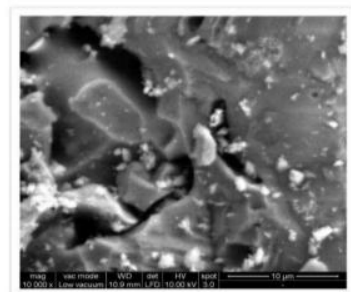
Fig 5.6: Results on 7.5k magnification of the SEM



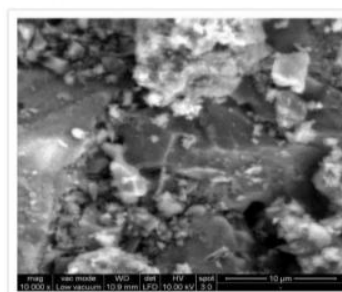
CONTROL ICB



0% of ICB



1.5% of ICB



2% of ICB

Fig 5.7: Results on 10k magnification of the SEM

From fig 5.6 and 5.7, we can observe the blurred appearance of hydration products in control ICB and formation of portlandite (Ca(OH)_2) crystals and prismatic crystalline crystals in 0% PF-ICB, 1.5% PF-ICB, and 2% PF-ICB varying in sizes. In comparing the 0% PF-ICB and 2% PF-ICB, the size of calcium silicate hydrate (C-S-H) is much larger in 2% PF-ICB which results in the high Moisture absorption test, compression test, and split tensile test. In 2% PF-ICB, the voids get filled by the plastic fibres showing fewer voids in the SEM test, whereas the 0% PF-ICB having no plastic fibres showed the presence of the void.

Comparing 1.5% PF-ICB and 2% PF-ICB, more voids can be seen in 1.5% of ICB, and also there's a better mortar and aggregate bond in 2% of ICB. The hydration products formed more in 2% of ICB leading to a high Moisture absorption test, compression test, and split tensile test.

CHAPTER 6

CONCLUSION

This review investigated the possibilities of using ripped plastic wastes and ceramics as commodities for manufacturing sustainable interlocking blocks. The inclusion of polypropylene fibres and ceramic waste improved the mechanical performance of the composite materials, such as strength properties, split tensile, and moisture content. Test results on the cemented interlocking blocks demonstrate that when polypropylene fibre is introduced, the interlocking blocks exhibit increased compression and split tensile strength. It's also possible to establish that interlocking blocks incorporating polypropylene fibres consume less moisture than specimens that don't.

Ultimately, the results of this research revealed that:

Polypropylene fibre is an appropriate source for making interlocking concrete blocks. The compression and split tensile strength of interlocked bricks, and water absorption were enhanced when the polypropylene fibre concentration increased. However, replacing 20% of the sand with broken ceramic strengthened the compression and split tensile strength of the bricks.

The SEM evaluation revealed that the formation of calcium silicate hydrate (C-S-H) , portlandite (Ca(OH)_2) crystals, and prismatic crystalline crystals is more in 2% PF-ICB and blurred formation in control mix ICB. Due to the presence of larger hydration particles in 2% PF-ICB, it resembles Low water absorption carrying capacity, high compression strength, and high split tensile strength.

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI,
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This is to certify that **VIKRANT MISHRA** of Sathyabama Institute of Science and Technology has presented the paper titled **EXPERIMENTAL INVESTIGATION ON INTERLOCKING CONCRETE BLOCKSMADE USING PLASTIC FIBRE AND CERAMIC AGGREGATES** in the International Conference on **Science, Innovation, Sustainable, Technology - Safety, Health and Environment 2022 (SIST-SHE22)** conducted by the Department of Biomedical, Chemical and Civil Engineering, Sathyabama Institute of Science and Technology, Chennai, on 8th - 10th March, 2022.

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