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UTILISING RECYCLED PLASTIC WASTE IN CEMENTITIOUS MATERIALS FOR SUSTAINABLE WASTE MANAGEMENT IN LARGE-SCALE CONCRETE APPLICATIONS

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Abstract.
Studies on the use of waste plastic particles in concrete provide a desirable way to control the need for coarse aggregate as well as an efficient way to manage waste related to the removal of plastics that are not biodegradable from the environment. In this study, it is focused to find an approach to dispose massive quantity of plastic waste which is constantly considered as great menace in the environment through large scale concrete applications specifically construction of concrete pavements in road works, industrial floorings etc. The waste plastic particles were collected from scrap and shred to a small particle size. In this work, the properties of concrete that contained waste plastic particles partially substituted for coarse aggregate were examined. It has been observed that the presence of plastic particles negatively affects the strength qualities of concrete; nevertheless, experimental research has demonstrated that adding 20% fly ash as an additional cementitious material greatly enhances the strength capabilities of concrete containing plastic particles. This technique shows an environmentally beneficial approach to natural resource conservation and enhances cumulative benefits for the removal of the increasingly dangerous plastic trash in the environment.

Keywords: Plastic waste, Waste management. Recycling, Strength Characteristics, Permeability, Sustainability

Introduction

In many parts of the world, fast industrialization and economical revolution brought incredible changes in life style of the people where solid waste is generated rapidly everywhere. It is reasonable to identify plastic waste as partial component in the final stream of Municipal Solid Waste (MSW). The development of the new generation of building materials is accelerating. It is advised to use waste widely for environmental reasons, yet some waste may be too unsafe to employ (Baciu and Kiss, 2020). In addition to a few additional unique waste streams, including packaging, there are significant annual amounts of garbage produced from both manufacturing and population. The first places where the plastic packaging ends up are the recycling facilities or the trash dismisses (Plastics Europe, 2020). In the present era, usage of plastics in our daily lives in abundant appliances is inevitable and the major forms in utilization include bags, covers, packaging films, containers, coating, wiring and many sorts of house appliances etc. The various components of plastic are used for about 41% in packaging industries, 20% in building construction, 15% in distribution and large industries, 9% in electrical and electronic, 7% in automotive, 2% in agriculture and 6% in other users (Gu and Ozbakkaloglu, 2016).

The main types of plastics are thermoplastics and thermosets, where thermoplastics serve as the main component but are covered with recyclable materials. Thermoplastics come in a number of different kinds, including Low Density Poly Ethylene (LDPE), High Density Poly Ethylene (HDPE), Polypropylene (PP), Polyethylene Terephthalate (PET), Polyvinyl Chloride (PVC), Polystyrene (PS), etc. Thermoset plastics are available in a variety of forms, such as Melamine Formaldehyde, Alkyd, Ester, Phenolic Formaldehyde, Metalised and Multilayer Plastics, Epoxy, Silicon, Polyurethane, etc. The primary plastic consumed is thermoplastic, which is used for conventional purposes such as packaging, textile fibres, and coatings etc. (CPCB Report, 2013). The main categories of plastic waste components and their underlying materials are listed in Table 1.

Table 1 Categories Of Waste Plastics
(Source: CPCB Report 2013)

Short Name	Scientific name	Used in
PET	Polyethylene Terephthalate	Water bottles, PET Bottles, etc
HDPE	High Density Polyethylene	Milk detergent Bags, carry bags, Container etc.
PVC	Polyvinyl chloride	Cables, pipes, Floorings, etc
LDPE	Low density Polyethylene	Carry bags, films
PP	Polypropylene	Medicine bottles, cereal liners, Packing films etc.
PS	Polystyrene	Foam Packing, Tea cups, ice cream cups, etc.
O	Others	Thermo Plastics, Multilayer & Laminated Plastics, PUF, Bakelite, Polycarbonate, Melamine, Nylon etc

Generally, after the intended purpose, these wastes are not disposed in a compatible manner and hence lead to redundant refuse on the landscape. Thus, waste plastic is a growing menace and become a serious concern worldwide owing to the non-biodegradability nature and unpleasant appearance. Hence it is necessary to arrive alternate methods to dispose the plastics in an eco friendly manner. Constraints of land use for the disposal of non bio degradable plastics and the related problems are the major concern in many developing countries (Kou et al. 2008). Recycling is one of the important process in 4R conception for the reduction of the growing volume of plastic wastes. Recycling procedures should consider the economic feasibility and the overall commercial viability of the desired reprocessing techniques the recycling chain (Lazarevic *et al.* 2010).

Natural bio degradation of plastics is an extremely time-consuming process. Through photo degradation plastic resin can be broken down, where process may extend over decades. Even longer, biodegradation of plastics lengthens for centuries. The final destination of major part of waste plastic is either a landfill where it does not decompose or an incinerator where harmful chemicals released into the air when they were burnt (Singh and Sharma, 2016). In the current scenario, construction works widely support usage of industrial by products like Metakaolin, Fly ash, Silica fume, Steel slag, Blast furnace slag, Discarded plastics and glass etc. which is an overwhelming trend towards sustainable environment approach. Selective plastic collection reduces waste incineration's profitability, discourages it, and directly improves air quality. PET recycling is still difficult to do in innovative ways (Bamigboye *et al.* 2019).

Usage of waste materials in construction also add many additional benefits such as saving in energy, issues of land filling etc. thereby decreasing the pollution of environment. Many research works carried out on the recycling applications of fly ash, copper slag, silica fume as auxiliary cementitious materials in construction practices worldwide (Albano *et al.* 2009). Research investigations reported about the usage of crushed brick as well as recycled concrete as aggregate and then to study the mechanical properties (Evangelista & de Brito, 2006), (Rashid et al. 2008), (Remadinia *et al.* 2009). It was stated that in Countries where natural rock deposits are scarce, it is necessary to identify an alternative source of coarse aggregate (Chen *et al*. 2005).

Caijjun Shi et al reported about the process of the effective utilization of the recycled colored waste glasses as coarse aggregate replacement material in cement concrete. Recycled rubber finds the selective application as substitute material in bituminous concrete mixes as filler material (Raghvan *et al*. 2020). The real challenge in recycling the wastes is reported to be the diversity of materials which includes food waste, paper waste, packaging materials, discarded electrical and electronic equipment along with intermingled plastic wastes (Gu and Ozbakkaloglu, 2016).

Usage of waste plastic particles as aggregate replacement material and also as filler materials in cement concrete mixtures were reported by numerous researchers (Choi *et al.*2004), (Elzafraney *et al.* 2005, Hannawi *et al.* 2010, Marzouk *et al.* 2006). David Lazarevic et al. 2010 stated that the review of various End-of –life technologies by Life cycle assessment studies indicated that mechanical recycling is the eco friendly preferred alternative towards waste management of plastic wastes.

This study aim to show that adding plastic to concrete along with fly ash, a suitable mineral additive, results in the development of a sustainable concrete with notable strength features. Considering the excessive quarry use to produce new conventional aggregates for concrete, recycling the abundant volume of plastic waste can cut down the use of natural resources in building construction.

2. Literature Review

Plastic trash is transformed into a secondary material that can be reintroduced into the system and used to make the same or different products with the same or different functionality (Maris *et al*. 2018). Particles/fibers made of polymeric materials can greatly minimize shrinkage cracking in concrete elements. The primary uses of this concrete are pavements, prefabricated tiles, borders, and pedestrian walkways which are also proven methods for the massive recycling of waste plastics (Baciu *et al.* 2022). While the percentage of plastics used to substitute sand is increased from 10% to 20%, the density of concrete based on plastic particles tends to drop by 5% to 8% when compared to the reference mix (Hannawi et al. 2010). Investigations on rubber shreds reported that incorporation of rubber particles improve workability of mixes considerably (Raghvan *et al.* 2020). Zoorob and Suparma (2000) investigated the usage of waste plastic concrete and concluded that incorporation of plastic aggregates in asphalt mixes to mixes with lower density as well as superior mechanical properties.

Despite their potential for recycling, plastic materials are rarely used and only a small portion is returned to production processes through reuse and recycling practices (Mwanza and Mbohwa, 2017). To give a thorough study on recycling plastics as construction material, various types of plastic wastes, recycling techniques, and the influence of plastic components on the parameters of concrete mixtures were compared with control concrete mixes reported in 84 investigations (Choi *et al.* 2004). Many studies reported about grinding of plastics in to reduced size in a grinding machine to make a suitable fraction for substitution as alternate aggregate. Researchers have looked into the possibility of creating recycled plastic fibres simply by mechanically cutting PET bottles in order to lower production costs (Fraternali *et al*. 2011). Two of the best qualities of plastics are their endurance and longevity, which enable the creation of robust items with low maintenance requirements and lengthy lifespans that are extremely cost-effective (Ragaert *et al.* 2017). Different types of crusher like propeller crushers or blade mills are used to grind the plastic waste. However, in some studies, plastic garbage of the appropriate sizes was gathered from plastic manufacturing or waste treatment facilities (Shayan and Xu, 2004), (Frisch, 1999). In this case, sieving into suitable size range was done at the

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laboratory (Saikia and De Brito, 2012), (Pesic et al. 2016). It is also reported that washing stage should be adopted to remove impurities present in the plastic wastes (CPCB Report, 2019). Separate grinding steps are also adopted after normal shredding to increase the cement paste–plastic aggregate bonding (Dewil *et al.* 2006). Elzafraney *et al.* (2005) reported that the recycled plastic particles could be used as aggregate in concrete mixtures which also be considered as energy efficient construction approach.

It is essential to design a detailed assessment system of the current and future scenario and to establish model facilities with environmentally friendly waste management approaches at the earliest. A study discovered that it is a feasible idea to replace 10% of the volume of sand with recycled plastic, which could save 820 million tonnes of sand annually. (Needhi 2020). If plastic bottles are used as coarse aggregate in concrete mixing, the cost of gravel can be reduced by 37% economically. (Siddiq 2020). Additionally, it has been observed that utilising 34% recycled plastic in concrete instead of sand results in less raw material extraction, which reduces fuel and carbon emissions. (Kaur and Pavia 2019). Niti Aayog (2022) reported on the environmental threat of single use plastics and recommends Bio Plastics, Bio degradable plastic, Compatible plastic and Oxo degradable plastic etc. It is also emphasised that, based on current production and waste management trends, 12,000 MT of plastic garbage would have been accumulated in the environment by 2050 if the current pace of production had continued.

3. Experimental Investigation

In this study, waste plastic elements collected from various consumer sectors are shredded into small particles and used successfully as partial coarse aggregate replacement material in cement concrete as weight percentages ranging from 0% to 25%. As the procedures do not involve any additional preparation such as melting, cleaning and sorting of plastic waste etc. the concrete composites recommended in this experimental investigation appeared to offer an attractive low- cost material and also help in resolving some of the solid waste problems created by plastics disposal in the environment.

Mix specification – Series I listed in Table 2 was prepared with varying plastic waste content as replacement to coarse aggregate in concrete and Series I strength test results show that the use of plastics in concrete lowered the strength of resultant concrete. Therefore, the study was oriented as Mix specification – Series II in Table 3 with the inclusion of 20% fly ash as additive material to Series I mix proportion that helps in overcoming the drawback of declining observations of strength parameters of plastic concrete. Grade M20 concrete mix with w/c ratio of 0.50 was adopted.

Table 2 Mix Specifications –Series I

Mix Specification	**Control mix CC**	**PC1**	**PC2**	**PC3**	**PC4**
Proportion of plastic waste with coarse aggregate	0%	10%	15%	20%	25%
Percentage of Flyash	0%	0%	0%	0%	0%

Table 3 Mix Specifications –Series II

Mix Specification	Control mix CC	PC1	PC2	PC3	PC4
Proportion of plastic waste with coarse aggregate	0%	10%	15%	20%	25%
Percentage of Flyash	20%	20%	20%	20%	20%

The workability was evaluated by conducting slump test in accordance with IS: 1199 procedure. Slump was immediately observed following the mixing procedure which was presented in Table 4.

Table 4 Workability Observations

Mix CC (0% plastic & 0% Fly ash) – 68mm Slump

MIX Specification	Slump(mm)	MIX Specification	Slump(mm)
Mix PC1	**65**	Mix PCF1	**67**
Mix PC2	**58**	Mix PCF2	**65**
Mix PC3	**54**	Mix PCF3	**62**
Mix PC4	**43**	Mix PCF4	**62**

The Workability test results show that workability decreases with increase in the plastic particle content which is reported by Islam et al. (2016). It is observed that the irregular shape of plastic particles attributes the reduction in workability indices due to irregular packing of plastic particles between the cement matrix. In Series II mixes, improvement in workability was observed when compared with Series I mixes which indicates that presence of Fly ash in Series II mixes offer the improved workability.

Manikandan and Ramamurthy (2009) described the role of fly ash in silica fume concrete leads to reduction in water demand and super plasticizer dosage. It was elucidated that the use of fly ash as a mineral additive to concrete improves its workability, durability, and long-term strength. The author illustrated that silica fume due to its like particle size increases the water demand and has a tendency to consume higher dosage of super plasticizer whereas fly ash due to presence of spherical particles that easily rollover one another reducing inter particle friction leads to improved workability. Bataeyneh et al. (2006) reported about the reduction in slump observed when plastic particles proportioned as partial replacement to fine aggregate in concrete. The author narrated that owing to the shape and sharper edges of plastic particles, the slump value was reduced.

3.1. Tests on hardened concrete:

Compressive strength tests were carried out on 150 mm cube specimens to evaluate the strength development of concrete containing plastic waste contents at the age of 7, 14, 28 days respectively. Cylindrical specimens (150mm x 300mm) and beam specimens (100x100x 700mm) were also cast for

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finding the Split Tensile strength and flexural strength on 7, 14, 28 days for each mix specification following the standard test procedures.

Remadinia *et al*. (2009) investigated about the use of silica fume in improving the pore structure of cement concrete and reported that the extreme fine size of silica fume particles facilitates the filling of voids between the cement matrix and aggregates. This filler effect is observed to be accountable for the improvement of the density and refinement of the pore structure of the concrete. Table.5 and Table.6 show the compressive strength and split tensile strength observations respectively. Fig.2 and Fig.3 represent the variations of strength properties of plastic concrete with and without fly ash.

Table 5 ***Compressive strength test results***

% of Plastic waste added	Concrete mix without Fly Ash	Compressive strength N/mm^2	Concrete mix with 20% Fly Ash	Compressive strength N/mm^2
0%	Control Mix CC	28.05	Control Mix CC1 (with fly ash)	34.10
10%	PC1	22.40	PCF1	31.47
15%	PC2	19.05	PCF2	30.05
20%	PC3	16.32	PCF3	29.46
25%	PC4	14.05	PCF4	22.36

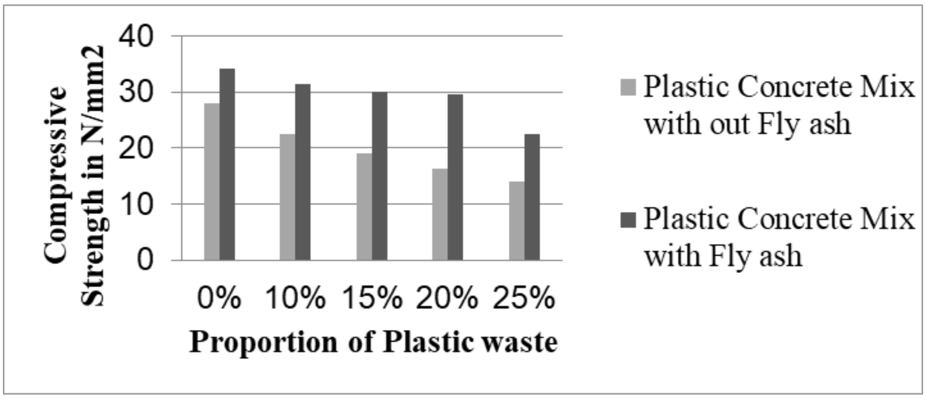

Fig. 1 Compressive Strength Observations

Table 5 and Figure 1 show that the compressive strength decreased with the increase in plastic aggregates percentage in concrete mixes substituted with plastic particles. It was also observed that the plastic concrete specimens exhibit an average 28% strength in the case of plastic concrete mixes without fly ash (PC Mixes) and an average 17% strength reduction observed in the case of plastic concrete mixes with fly ash (PCF mixes) when compared with conventional concrete (CC & CC1). The presence of fly ash particles encourages more efficient filler effect on cement matrix packing, which accounts for the positive effects of fly ash on strength (Zainab *et al*. 2007). In both PC And PCF mix series substitution of plastic particles more than 20% lead to drastic strength reduction. Kou *et al*. (2008) observed that the compressive strength of concrete incorporated with PVC granules was reduced with increased percentage substitution of PVC granules when compared with control mix.

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Similar observation was reported by Marzouk *et al*. (2006) and the author concluded that with the substitution of plastic aggregates more than 50%, the mechanical properties of plastic concrete mixes drastically fall.

Table 6 ***Split Tensile strength test results***

% of Plastic waste added	Concrete mix without Fly Ash		Concrete mix with 20% Fly Ash	
	Mix ID	Split tensile strength N/mm^2	Mix ID	Split tensile strength N/mm^2
0%	Control Mix CC	4.53	Control Mix CC1 (with fly ash)	5.30
10%	PC1	4.40	PCF1	5.26
15%	PC2	3.50	PCF2	5.08
20%	PC3	2.96	PCF3	4.62
25%	PC4	1.92	PCF4	3.90

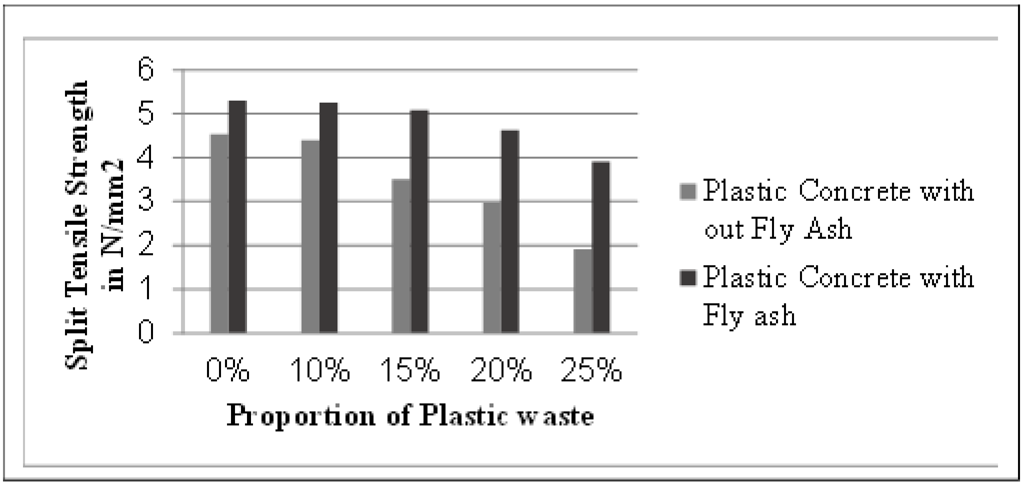

Fig. 2 Split Tensile Strength Observations

In resemblance with compressive strength test results, a similar observation was made about the splitting tensile failure of specimens evaluated under compression force, as shown in Table 6 and Figure 3. It was observed that 20% fly ash addition to cement in concrete in the case of PCF series of mixes results in a denser concrete mixture and thereby an average 40% enhancement in strength was achieved in Series II – Plastic particles based mixtures with fly ash when compared with Series I- Plastic particles based mixtures without fly ash. The addition of mineral admixtures like silica fume, fly ash reduces the porosity of concrete and helps making a dense concrete. The reactive silica present in the fly ash addition in PCF mixes combines with free calcium hydroxide to form additional Calcium-Silicate-Hydrate (C-S-H) gel product in the concrete. This secondary hydration process is beneficial in consuming the calcium hydroxide in the concrete which increases the density of the concrete and also refines the pore structure.

However, strength reduction is common in both PC and PCF mixes with more than 20% plastic substitution in concrete. Albano *et al.* (2009) reported that the splitting tensile strength was lowered

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due to the increased percentage of incorporation of PET aggregates in concrete as alternate aggregate. Al- Manaseer and Dalal (1997) reported that reduction in split tensile strength observed with the increase in percentage of plastic aggregate substitution in concrete. Pesic *et al.* (2016) discussed that the tensile strength and flexural modulus were improved marginally with the presence of HDPE fibres owing to the flexural ductility offered by the fibres.

3.2. Flexural strength observations of R.C.C.Beams

The experimental program consists of testing reinforced concrete beams of size 150mm x 150mm with an overall length of 1500 mm. The beam specimens were prepared with plastic particles as weight replacement of coarse aggregates ranging from 10% to 25%. Two series of specimens were prepared in which PC1, PC2, PC3 and PC4 are beams without the substitution of fly ash as additive material to cement in concrete whereas which PCF1, PCF2, PCF3 and PCF4 are beams with the substitution of fly ash as additive material to cement in concrete. Control specimens were prepared without the substitution of plastic aggregate and fly ash. Two point loading system was adopted for the test and the load vs. deflection observation of the beam was carried out at regular load intervals.

The flexural strength was determined using the following expression

$$Fcr = PL / bd^2$$

Where Fcr = modulus of rupture P = ultimate load in KN L = length of beam in m
b = Average width of specimen in m d = Average depth of specimen in m

Table 7 Flexural strength test results of R.C.C. Beams

S.No	**Mix ID**	**Ultimate Load (kN)**	**Maximum displacement**	**Flexural strength**
Plastic aggregate based concrete without flyash				
1	CC	7.80	1.20	3.47
2	PC 1	6.80	1.20	3.02
3	PC 2	6.40	1.25	2.84
4	PC 3	5.80	1.29	2.57
5	PC 4	4.90	1.55	2.17
Plastic aggregate based concrete with 20% flyash				
1	CC1	9.20	1.10	4.08
2	PCF 1	9.28	1.00	4.12
3	PCF 2	8.96	1.00	3.98
4	PCF 3	8.50	1.10	3.70
5	PCF 4	6.50	1.50	2.71

Table.7 shows the results of flexural strength test conducted on R.C.C beams of plastic aggregate based concrete with and without fly ash. It was observed that the tested beams failed in flexure with crushing of concrete in the compression zone at the failure stage following the development of flexural cracks. The first visible cracks appeared in the region of maximum bending moment between the locations of the two point loads.

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Load Vs deflection observations of concrete beam specimens showed that deflection increases with increase in percentage plastic content however the flexural strength observations showed that there was decrease in strength of the beams with increase in the percentage substitution of plastic particles as weight replacement to coarse aggregate in concrete. Zainab *et al.* (2007), Jibrael and Peter (2016) investigated the flexural strength of concrete incorporated with 10%, 15% and 20% plastic waste partial replacement material to fine aggregate in concrete. The authors observed that the flexural strength of plastic waste based concrete mixes was reduced considerably with increased percentage substitution of plastic waste.

Similar observation was reported by Saikia and de Brito (2012) that the flexural strength of concrete was lowered considerably for concrete containing PET aggregate when compared with concrete containing natural aggregate alone. However, significant improvement in flexural strength observation was achieved with addition of 20% fly ash to cement in concrete. Previous studies done by Shayan and Xu (2004) also reveal that waste glass has an effective utilization of about 17% in concrete as aggregate.

3.3.Permeability Observations

Permeability of concrete is one of the significant parameter related to durability observations of normal concrete applications because it controls the pace of entry of moisture which may contain aggressive chemicals and the movement of water during heating or freezing. Higher the permeability lesser will be the durability. Permeability observations of plastic concrete provides an insight into the influence of plastic particles on the porosity parameters which would have helpful in arriving useful discussions on the preparation of pavements using plastic concrete mixtures. Permeability of concrete primarily depends upon the pore structure of concrete such as porosity, sorptivity etc. Hence, the tests were carried out as per ASTM C 642-1997 procedures and the parameters observed were saturated water absorption, porosity and sorptivity Pore structure observations of control concrete and Plastic concrete mixes were presented in Table 8.

Table 8. Permeability Test Results

Observation Parameter	Mix CC	Mix PCF1	Mix PCF2	Mix PCF3	Mix PCF4
Saturated water absorption in %	2.20	3.52	3.78	3.88	5.15
Porosity in %	6.05	7.06	7.45	7.88	9.20
rSorptivity in mm/√min	0.0770	0.0800	0.0885	0.0920	0.1905

Pore structure observations reveal that all plastic concrete mixes show higher porosity probability when compared with porosity parameters of control concrete. Among that, PCF 4 mix substituted with 25% plastic particles show incomparable values of pore structure observations are evidence for a restriction that substitution of plastic particles more than 20% is not desirable. It is observed that dispersion of plastic particles in concrete append inter-particle voids which may be assumed to contribute to the increase in saturated water absorption, porosity and sorptivity as all these factors are closely related to voids in concrete. Likely, Fraternali *et.al.* (2011) came to the conclusion that using recycled PET fibres in concrete is a viable technique to improve the ductility, strength and thermal resistance of concrete. These observations are vital aspects to make structural components with improved energy performance as well as sustainablity to reduce the environmental impact of plastic waste.

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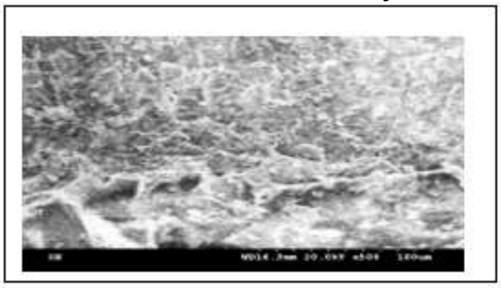
3.4. Scanning Electron Microscope (SEM) Observation

After 28 days of curing, samples from core of concrete cube specimen were extracted and subjected to Scanning Electron Microscope observation. The particle size distribution of plastic waste particles as dispersed in concrete was observed by SEM and illustrated in Figure 3 to Figure 7.



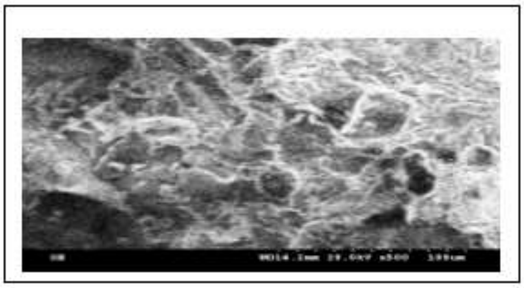
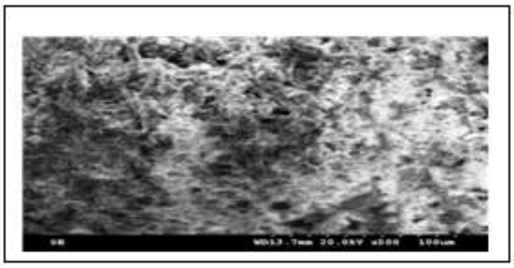


Fig. 3. Control concrete – 0% plastic

Fig. 4. Dispersion of 10% plastic in concrete



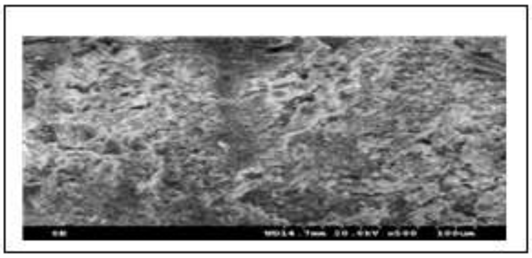


Fig. 5. Dispersion of 15% plastic in concrete

Fig. 6. Dispersion of 20% plastic in concrete

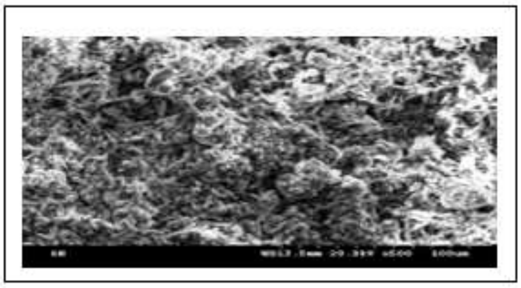


Fig. 7. Dispersion of 25% plastic in concrete

The SEM observation reveals that the packing of concrete was not influenced by the plastic particles in the lower range of replacement which may be considered as approximately less than 20% and it is also observed that the discrete plastic particles do not possess the cementitious property. The inter transition zone (ITZ) between cement matrix and plastic aggregates was observed to be ample when comparing with natural aggregates.

In general, plastic aggregates restricting the hydration reaction near its surface owing to the smoothness and hydrophobic nature of plastic particles was reported by Shayan and Xu (2004). Fly ash added as additive material which acts as a filler material and reducing the porosity of the concrete. However, concrete mixtures with substitution of more than 20% plastic particles exhibit concrete with excess porous structure which could also affect the morphology, strength and durability of concrete mixture.

Conclusion:

Following are the conclusions made based upon the experimental study:

- Previous studies have been done on the possibility of waste glass and plastic as aggregate in concrete Zainab *et al.* (2007), Chen *et al.* (2005). In line with this aspect, it was identified that plastic waste can be reused as construction material. Based on the particle size the plastic waste can be used as filler material in concrete rather than aggregate material.
- The study of workability of plastic concrete revealed that with increased content of plastic in concrete, marginal variations in slump were observed. The irregular packing of concrete with plastic particle as aggregate replacement material has influenced the workability much in the case PC4 and PC5 mixes and surface level dispersion of plastic particles was inevitable in these mixes.
- From the compressive strength tests, it has been observed that waste plastic as filler material used in this investigation leads to reduction in strength compared to control mix. Significant improvement in strength was found in the compressive strength of concrete with the presence of waste plastic as filler material and fly ash as 20% weight replacement to cement in concrete. It was observed that the average percentage of compressive strength gain of plastic concrete with fly ash was about 61 % higher than plastic concrete without fly ash.
- The experimental observations reveal that the effective percentage utilization of plastic waste of 15% - 20% as filler material in concrete was satisfactory. Needhidasan and Sai (2020) concluded that 20% E- plastic waste can be used to replace the coarse aggregate in M60 grade of concrete with acceptable strength properties.
- By preparing concrete pavements, precast units etc. based on plastic aggregates, the use of these waste materials in concrete offers a partial solution to the disposal problems related to the massive amount of plastic garbage clearance from the environment which is in coherence with the findings of Yin et al. (2015).
- This investigation has been shown to be advantageous from sustainable environment considerations and the use of plastic waste as a replacement for coarse aggregate in concrete mixes appears feasible to find an environmentally friendly, cost-effective utilization of plastic waste as filler material in concrete pavements.

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