Global NEST Journal, Vol 25, No X, pp 1-10

Concrete constructed with recycled water to experimental analysis of the physical behavior of polypropylene aggregate (PPA)

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Received: 03/01/2023, Accepted: 26/01/2023, Available online: 10/02/2023
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https://doi.org/10.30955/gnj.004723

Graphical abstract

Abstract

In concrete industry, the use of concrete solid wastes is becoming further common since it can minimize associated costs and environmental implications. The current research looks at how concrete performs when polypropylene (PP) plastic, produced from pollution garbage items, is used as a partially replacing for coarse aggregate (CA). The proportion of total PP (PPA) (0, 5, 10, 15, and 20%) as well as the water-cement ratio 0.45 of recycled household wastewater, are the most important variables. Flow ability, hard porosity, maximum compressive strengths are all factors to consider, and economic feasibility are all discussed. The slump value grew when the proportion of PPA was raised, according to the findings. Compressive and cracking tensile strengths were increased in concrete containing 15% PPA. As a result, suggested to utilize more than 10% PPA in structural concrete, with either crushed stone or PP aggregate. The results showed that 15% is the best alternative to coarse gravel during terms of strength and durability, and hence PPA can be utilized as a partial replacement for coarse aggregate in concrete. To conduct studies to enhance the impact resistance of concrete by utilizing recycled water. Reducing the consumption of nonrenewable resources reducing greenhouse gas emissions and improving the strength and load capacity of industrial materials used in building research. Finally, employing non-biodegradable waste plastic resources to make green concrete will offer up new possibilities.

Keywords: Polypropylene aggregate, concrete, non-biodegradable, green concrete

1. Introduction

One of the most important characteristics of any type of infrastructure is its sustainability, which would be determined by implications on the economy and the environment. One of its most popular building materials is cement extensively utilized as the world's largest construction activity, out of all options (Mohammed *et al.*, 2015). Raw materials are often used to make 13.12 billion tonnes of concrete each year building to meet this demand. Natural resources are becoming scarce as a result of the rising demand for construction materials. Experts, on the other hand, are responding favorably to this demand by offering novel formulations based on alternative elements. The use of possible plastic wastes as aggregate in concrete can help to lessen reliance on natural aggregate while also lowering production as well as shipping expenses. In addition, reduce related expense & location with for intention of eliminating disposal while having no negative impact on the environment (Okoffo *et al.*, 2021).

Of its minimal cost, low weight, strength, & processability, and construction, plastic has been the most extensive product used in the workplace and society for over an era. Between 1950 and 2016, the use of synthetic materials increased by -5 to 368 million tonnes. In 2018, about 35.7 million tonnes of plastic garbage were created in the United States, compared to 61.8 million tonnes in Europe (Rajkumar *et al.*, 2020). China and India are the two countries in Asia that use the most plastic. During the years 2010–2011, roughly 0.75 million tonnes of plastic made from polymers trash have been manufactured in

Bangladesh (Liang *et al.*, 2021). Polypropylene (PP) and high-density polyethylene (HDPE) represent the most often used materials in the plastics industry (Ozbakkaloglu *et al.*, 2017). PP (19.1 percent) was the most popular plastic in Europe in 2015, followed by LDPE (17.3%) (Saravanan *et al.*, 2021). In 2013, the world generated approximately 55 million tonnes of PP (D'Ambrières, 2019). In 2012, PP was the second most extensively used plastic in the United States (7.2 million tonnes), accounting for 22.6 percent of all ductile items; nevertheless, and maximum proportion of each vast PP volume that was recycled was quite low (0.6 percent). The majority of Toxic garbage is recyclable, and yet its incorrect disposal poses a serious hazard to soil and the ecosystem. Proper waste management is necessary to address this major issue of trash disposal (Islam *et al.*, 2016; Ozbakkaloglu *et al.*, 2017; Saravanan *et al.*, 2021). When subjected compressive strength is reduced when exposed to extreme heat, particularly the concrete with a higher PP content fell dramatically. Furthermore, PP aggregate concrete (PAC) has lower workability and density than reference concrete (Kurup and Kumar, 2017).

Water is an essential component in the production of concrete because of the important role it plays in cement hydration and the workability of fresh concrete. Only potable water has always been used for mixing and curing concrete. Concrete's consistency and slump can be increased by up to 12 to 14% when recycled water is used.

The use of plastic waste as aggregate in concrete has the potential to be more sustainable than the use of natural aggregate in some cases. This is because using plastic waste as aggregate reduces the amount of plastic waste that ends up in landfills, which can help to reduce environmental pollution and preserve natural resources. Additionally, using plastic waste as aggregate can reduce the need for mining and quarrying, which can have negative impacts on the environment, including habitat destruction and water pollution.

One potential benefit is that using plastic waste as aggregate can reduce the overall cost of concrete production. This is because plastic waste is often cheaper and more readily available than natural aggregate materials, such as sand, gravel, and crushed stone. Additionally, using plastic waste as aggregate can reduce the need for mining and quarrying, which can be expensive and time-consuming.

In this experiment, the production of concrete included the use of polypropylene (PP) plastic as a partially replacing for coarse aggregate (CA). The concrete also included recycled household wastewater, with a water-cement ratio of 0.45. The proportion of total PP (PPA) varied in the experiment, with levels of 0, 5, 10, 15, and 20% being tested.

The compressive and cracking tensile strengths of the concrete were also increased when it contained 15% PPA. Based on these findings, it was suggested that more than 10% PPA could be used in structural concrete, either with crushed stone or PP aggregate. The results also showed that 15% PPA was the best alternative to coarse gravel in terms of strength and durability and that PPA could be used as a partial replacement for coarse aggregate in concrete.

There are several potential benefits of using plastic waste in concrete:

Reduction of plastic waste: One of the main benefits of using plastic waste in concrete is that it can help to reduce the amount of plastic waste that ends up in landfills, which can help to reduce environmental pollution and preserve natural resources.

Increased efficiency: Using plastic waste as aggregate in concrete can also improve the efficiency of the concrete production process. This is because plastic waste is typically lighter than natural aggregate materials, which can make it easier to transport and handle. Additionally, using plastic waste as aggregate can reduce the amount of water needed in the concrete mix, which can improve the efficiency of the production process.

Improved performance: In some cases, using plastic waste as aggregate in concrete can also improve the performance of the concrete, including its strength and durability. This is because the specific properties of plastic waste can have positive effects on the properties of the concrete.

Plastic waste that is not properly managed can end up in landfills, where it can take hundreds of years to break down. It can also litter the landscape and waterways, where it can harm wildlife and have other negative impacts. Proper waste management can help to address these issues by ensuring that plastic waste is properly disposed of and recycled. This can include initiatives such as reducing plastic consumption, promoting the use of reusable containers, and implementing recycling programs.

In terms of porosity, crushed stone generally has a higher porosity than PP. This is because the crushed stone is a natural material that is made up of small pores and spaces, while PP is a synthetic material that is more homogeneous and has a lower porosity. As a result, concrete made with PP as a coarse aggregate may have a lower porosity and a higher density compared to concrete made with crushed stone. In terms of weight, concrete made with PP as a coarse aggregate may be lighter than concrete made with crushed stone. This is because PP has a lower density than many types of crushed stone, and it can therefore reduce the overall weight of the concrete. However, the specific weight and strength characteristics of concrete made with PP or crushed stone will depend on the specific properties of the materials used and the mix design of the concrete.

Plastic waste can vary in terms of quality, composition, and cleanliness, which can make it difficult to use consistently in products or materials. Plastic waste may be contaminated with other materials, such as food waste, dirt, or chemicals, which can make it difficult to use in certain applications. It is difficult and expensive to process and handle, especially if it is contaminated or in small pieces. While plastic waste can be used in a range of products and materials, there are still limits to its potential uses, and it may not be suitable for all applications.

The physical behavior of polypropylene aggregate (PPA) in concrete constructed with recycled water may depend on a variety of factors, such as the specific properties of the PPA and recycled water, the mixture proportions and curing conditions of the concrete, and the testing methods used to evaluate the concrete's performance was very much accurate when compared to existing works.

The use of plastic waste as a partial replacement for traditional aggregates in concrete can improve the strength and durability of the final product. The plastic particles can act as a binder and help to reduce the amount of cement needed in the mixture, which can lower the cost and environmental impact of the concrete. The plastic can also improve the concrete's resistance to cracking, shrinkage, and wear, and can enhance its ability to withstand extreme temperatures and harsh weather conditions.

The physical properties include Fineness, soundness, setting time, and compressive strength. The chemical properties include the percentage of loss on ignition, percentage of magnesia, insoluble residue, sulphuric anhydride, total chloride content, net proportion of lime to silica, alumina, and iron oxide

Fineness: The fineness of cement refers to the size of the cement particles and can be evaluated by measuring the surface area of the cement particles.

Soundness: Soundness is a measure of the cement's ability to retain its volume after hardening.

Setting time: The setting time of cement refers to the time it takes for the cement to harden and reach a certain level of strength. The setting time of cement is an important factor that affects the construction schedule and the workability of the concrete mixture.

Compressive strength: The compressive strength of cement is a measure of its ability to withstand applied pressure.

Percentage of loss on ignition: The percentage of loss on ignition is a measure of the amount of volatile matter present in cement. It is determined by heating a sample of cement to a high temperature and measuring the weight loss.

Percentage of magnesia: The percentage of magnesia in cement is a measure of the amount of magnesium oxide present in the cement.

Insoluble residue: The insoluble residue of cement is a measure of the amount of undissolved material present in the cement. It is determined by mixing a sample of cement with water and filtering the mixture to separate the dissolved and undissolved fractions

Sulphuric anhydride: The sulphuric anhydride content of cement is a measure of the amount of sulfur trioxide present in the cement.

Total chloride content: The total chloride content of cement is a measure of the number of chloride ions present in the cement. Chloride ions can corrode steel reinforcing bars in concrete.

Several types of plastic are commonly used in the construction industry, including polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC), polystyrene (PS), and polyethylene terephthalate (PET). Each of these plastics has unique properties and is used for specific applications in construction.

The purpose of this experimental study was to investigate the physical behavior of polypropylene aggregate (PPA) in concrete constructed with recycled water. The study may have been designed to evaluate the effects of using PPA and recycled water on the strength, durability, and other properties of the concrete, and to determine the optimal mix design and curing conditions for producing high-quality concrete using these materials. Other potential objectives of the study include evaluating the environmental and economic benefits of using PPA and recycled water in concrete production, comparing the performance of concrete made with PPA and recycled water to that of concrete made with traditional materials, and identifying any potential challenges or limitations associated with using these materials in concrete construction.

Several methods can be used to evaluate the quality of fine and coarse aggregates in concrete. Some common methods include the following: Sieve analysis, Specific gravity, Absorption, Soundness, Abrasion resistance, Shape, and surface texture.

2. Literature review

An inventive method of producing sustainable green concrete while preserving natural resources and reducing landfill load is by using recycled replacement pieces in mortars (Jeyabalaji *et al.*, 2021; Albano *et al.*, 2009; Kan and Demirboğa, 2009). There have been numerous investigations on raw polypropylene fiber or composites consisting of polypropylene and PP particles of different fine sizes (Ridwan *et al.*, 2014; Vignesh Kumar *et al.*, 2021; Aneke and Shabangu, 2021; Karthik *et al.*, 2021). However, PP plastic has been used as coarse aggregate in a few studies (Tiwari *et al.*, 2016). As a result, the current research focuses on the flow ability, toughened densities, compressive, and tensile are all terms used to describe the properties of a material, and its cost-effectiveness as concrete As a recycled aggregate, polypropylene (PP) plastic is used (Sellakutty *et al.*, 2016).

Many studies have recently been published that look into the usage of various sorts of in-building projects' recyclable materials published a review evaluating a variety of waste replacement for fine aggregates in concrete, including dump trash, industrial garbage particles, blast furnace slag, plastic trash, regenerated rubber fiberglass debris, as well as rubbish (Faraj *et al.*, 2019). Summary research in this disposal of polymer recovery procedures impact such as their inclusion from properties in the form of cementitious materials (Haghighatnejad *et al.*, 2016). In examined use of waste items that have been repurposed with the construction of roadways. Recycled broken crystals, slags, steel fiber, rubber, polymers, as well as discarded gravel used are among the waste items that have been examined

(Mokhtar *et al.*, 2016). Offered an overview of the qualities of concrete that has been mixed with waste-recovered plastic. The impact on the mechanical production of biodegradable plastic qualities with long-term stability has been demonstrated (Vivek and Sashik Kumar, 2021). Additionally, a complete investigation of cement mortars that contain combinations of plastic was done. The utilization pebble debris with polyethylene terephthalate (PET) construction linked was critically examined (Leela Bharathi *et al.*, 2020; Jain *et al.*, 2019; Islam and Shahjalal, 2021). PET plastic bricks were utilized, according to another investigation examined development of fibers produced from waste materials being used to reinforce bricks provides a review on concrete mixture made with a variety of waste elements, including tyre waste, fly ash, blast furnace slag, fumed silica, and polymers agricultural garbage gave comprehensive analysis in usage of synthetic garbage component structures mixture of concrete (Raja *et al.*, 2020). And also examined the advantages and disadvantages of recovering polymer waste (Dombe *et al.*, 2020). There has been extensive research into the effects of plastering rubber and plastic trash into gravel (Mercante *et al.*, 2018). Further study was recently published on the use utilization waste material as concrete aggregate materials, its impact physical & lengthy dependability attributes (Shanmugamoorthy *et al.*, 2022). The feasibility using industrial by - products producing bitumen is examined and it was presented (Sivakumar *et al.*, 2022; Theja *et al.*, 2022).

There have been numerous studies on the use of recycled materials, including polypropylene (PP) plastic, as partial replacements for traditional aggregates in concrete. These studies have focused on a range of properties, including the flow ability, density, compressive and tensile strength, and cost-effectiveness of concrete made with recycled aggregates. Many of these studies have also examined the long-term durability and stability of concrete made with recycled materials, as well as the environmental and economic benefits of using recycled aggregates in construction. However, there have also been studies on the use of other types of recycled materials, such as rubber and plastic waste, in concrete and other construction materials. These studies have examined the impact of these materials on the mechanical properties and long-term stability of the resulting products. to overcome the drawbacks of the existing work this study presents an in-depth analysis of the suitability of various polymer trashes, including n number of plastic polymers, used in production for pavement design of masonry, ceramics, building frames, & mortar. The impact of waste plastics mostly on the quality and rigidity of finished goods is also discussed in this review study.

3. Experimental program

In terms of workability, mechanical strengths, and cost analyses, this study investigates the impact of PP aggregate as partial replacement for natural stone aggregates on various concrete qualities.

The use of recycled water slightly reduces the strength of concrete due to the presence of impurities that can interfere with the hydration process. However, the magnitude of this effect is likely to be small and mitigated by adjusting the concrete mixture proportions or using supplementary cementitious materials. The workability of concrete is also affected by the use of recycled water. Recycled water that is highly contaminated or has high salt contents reduce the workability of concrete by decreasing the water-cement ratio and increasing the water demand of the mixture. The recycled water with a lower salt content or that has been adequately treated may have little or no effect on the workability of the concrete.

The use of PPA as a partial replacement for coarse aggregate may also affect the density of the resulting concrete mixture. PPA has a lower density than traditional aggregates, and using a higher percentage of PPA in the mixture can reduce the overall density of the concrete. This can affect the strength and other properties of the concrete, as well as its weight and cost.

The use of PP as a partial replacement for traditional coarse aggregates in concrete can slightly reduce the compressive strength of the concrete, due to the lower density and lower specific gravity of PP compared to traditional aggregates. The magnitude of this effect may depend on the percentage of PP used in the mixture, the size and shape of the PP particles, and the properties of the other materials in the mixture.

3.1. Materials and methods

Cementitious (even as a binder substance), river coarser materials, including granular material, sand (including bottom ash), and plastic waste aggregate from PP were the components for concrete in this experiment. These materials were the subject of numerous investigations in order to ascertain their properties and create efficient concrete mix proportions.

3.1.1. Cement

The minerals' good quality (such as mortar) utilized as for construct structure can simply be assessed. Chemical and physical factors define the cement grade's quality. It is highly advised that before purchasing any cement, you verify to see if concrete qualities correspond to the guidelines of that organization IS standards represents in Tables 1 and 2.

3.1.2. Fine aggregate

The fine aggregate for concrete was riverbank sands, gathered and by a sources from the region. ASTM C136-14 standard was used to grade the sand (Mohanraj *et al.*, 2022). The manufactured sand grain sizes dispersion is shown in Table 3, and it conforms within the ASTM C 33-18 standard range (Sivakumar *et al.*, 2022). To evaluate sand absorption capacity and unit weight, ASTM C128-15 measurements of the sand's unit weight and water content were used. The physical characteristics of sand are listed in Table 3 (Shanmugamoorthy *et al.*, 2022; Sivakumar *et al.*, 2022; Theja *et al.*, 2022).

Table 1. OPC 43 Grade Cement Physical Characteristics (As per ASTM C 33-18)

Sl. No	Characteristics	Required Value
1	Fineness (by Blaines apparatus)	Not less than 225 m^2/kg
2	Soundness	
	(a) Le Chatelier method	Not more than 10 mm
	(B) Autoclave test	Not more than 0.8%
3	Setting time	
	(a) Initial setting time in minutes	Not less than 30
	(b) Final setting time in minutes	Not less than 600
4	Compressive strength	
	(a) 72 +/- 1 hour (3 days)	Not less than 27 MPa
	(b) 168 +/- 2 hours (7 days)	Not less than 37 MPa
	(c) 672 +/- 4 hours (28 days)	Min -43 MPa, Max – 58 MPa

Table 2. Chemical properties of OPC 43 Grade cement: IS: 8112 is the IS code for OPC 43 Grade cement (Sivakumar *et al.*, 2022)

Sl. No	Characteristics	Required value
1	Loss on ignition %	Not more than 4.0%
2	Magnesia %	Not more than 6.0%
3	Insoluble residue %	Not more than 4.0%
4	Sulphuric anhydride %	Not more than 3.5%
5	Total chloride content %	Not more than 0.10%
6	Net proportion of lime to Silica, Alumina and Iron oxide	0.66 – 1.02%
7	Net proportion of Alumina to Iron oxide	Not less than 0.66%

3.1.3. Coarse aggregate

The IS 383 standard outlines the specifications for crushed or uncrushed aggregates supplied from natural sources, including river terraces and beds, glacier deposits, rocks, boulders, and gravels, for use in the production of concrete for typical structural uses, like mass concrete buildings. The sieve test is the most common field test used to gauge aggregate quality. Sieve analysis cannot be used to measure parameters or shape attributes. Therefore, the creation of quick assessment methods is crucial for overall quality control.

Considering coarse aggregate accounts for majority of the density in mortar, its quality is critical for high-performance concrete. Crushed stone and waste polypropylene (PP) were employed as coarse aggregates as an experiment. Stone dust gravel used to obtain nearby crushing of rock with angular form and at least three cracked faces. Following steps were used to prepare waste PP aggregate: collecting, sorting, and washing, shredding, melting, chilling, and lastly crushing to the necessary size. The porosity PP aggregates was low in weight, angular, rough on the surface. Figures 1 and 2. Represents the particles made of pulverized rock, bricks, and PP waste. The total volume in percentage difference between the volume of the solid and the total volume of the ingredients is used to determine the porosity of the aggregate. And also Figures 1 and 2 represents about the porosity results (Islam *et al.*, 2016).

3.2. Quantities of concrete mix

The goal of this study is to evaluate the performance of PP aggregate concrete with natural aggregate concrete (NAC).Water-cement (w/c) ratios of 0.45. The selecting mix proportions for average weight concrete; the ACI Standard Practice was used (Sivakumar *et al.*, 2022). There was no admixture employed to reduce the amount of water in the combination. Proportions of various elements in a concrete mix for a cubic meter volume of concrete represented in Table 4. Each mix design has its own name to make referring easier within the text. SC45P3, for example, indicates that the mixture has a water-to-cement ratio of 0.45 & PP material account for 20% of the given quantity of crushed stone (Zulkernain *et al.*, 2021; Palanisamy *et al.*, 2022).

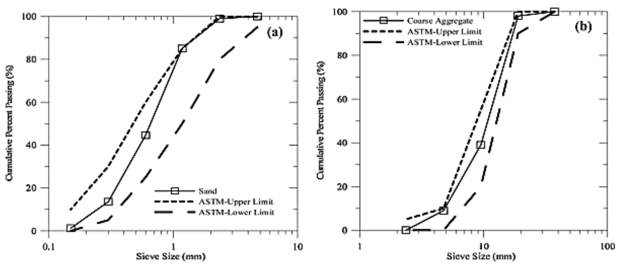

Figure 1. Particle size distribution of (a) and (b) coarse aggregate along with ASTM limits.

Figure 2. Coarse aggregate: (a) crushed stone aggregate (SA), (b) polypropylene (PP) aggregate

3.3. Concrete specimen preparation

At room temperature of 25°C, concrete cylinders with a diameter of 100 mm and a height of 200 mm were made according to ASTM C 192-15 (Palanisamy *et al.*, 2022). Concrete's compressive strength was assessed using cubic specimens at 7 and 28 days. Concrete's compressive strength was assessed using cubic specimens at 7 and 28 days. 150 x 150 x 150 mm were cast in order to determine the modulus of rupture at 7 and 28 days (Krishnaswami *et al.*, 2022). All of the Iron was used to create the specimens moulds, they were compacted with a vibrator. Sample was collected cured in laboratory setting with a 70% moisture contents and a temperatures around 23.2°C for first 20–24 hours after casting (Figure 4). During this phase, moist jute fabric and plastic sheets were used to thoroughly cover the specimens in order to avoid water loss by evaporation(Theja *et al.*, 2022; Vignesh Kumar *et al.*, 2021). After 20–24 hours of casting, moulds were removed, and inside a curing period, the samples have been positioned filled with liquid and kept for 28 days at 22°C(Vivek *et al.*, 2017; Anuradha *et al.*, 2016).

Table 3. Material properties of coarse aggregate (As per ASTM C128-15)

Properties	Coarse Aggregate		Fine Aggregate
	Stone	PP aggregate	
Maximum size of aggregate (mm)	20 mm	20 mm	2.36
Fineness modulus	6.55	6.55	2.56
Elongation index (%)	20	16	-
Flakiness index (%)	20	12	-
Specific gravity OD	2.6	0.8	2.38
Specific gravity SSD	2.60	-	2.42
Water absorption %	1.04	0.8	3.40
Loss by abrasion and impact %	33	-	

Table 4. Cementitious Proportion

W/C ratio	Design	Proportion of Coarse aggregate %		Cement (kg/m^3)	Water (kg/m^3)	Fine aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	
		CA	PP				CA	PP
0.45	Sample 1	100	0	382	191	716	1109	0
0.45	Sample 2	95	5	382	191	716	984	49.2
0.45	Sample 3	90	10	382	191	716	859	85.9
0.45	Sample 4	85	15	382	191	716	734	110.1
0.45	Sample 5	80	20	382	191	716	609	121.8

4. Results and discussions

4.1. Compressive strength test

In the laboratory, variations of mix proportions have been prepared to use a 5 cft cementitious material machine, when concrete mixture was laid on a concrete surface after mixing (Krishnaraja *et al.*, 2022; Shanmughan *et al.*, 2022). To determine the workability of freshly mixed concrete, a slump test is immediately conducted (Figure 5). The slump test was carried out in accordance with ASTM C143-15 (Theja *et al.*, 2022). Physical parameters of cementitious, physical characteristics, have examined using a 1500 kN capacity external characteristics instrument in Figure 3 (Velusamy *et al.*, 2022; Mohanraj *et al.*, 2022). After the compression test was conducted, which involves loading the test specimen between two plates and applying pressure to it by moving the graphical illustrations together, the 28-day curing process was completed. The specimen is crushed during the test, and deformation as a result of applying load is observed in UTM.

4.2. Flexural Strength test

Crushing toughness of the concrete samples was determined splitting tension resistance, and hardened density (Vijayakumar *et al.*, 2016; kumar and Subbulekshmi, 2017). The yield stress of beams was determined using a 1000 kN universal testing equipment (UTM) in accordance with ASTM C 293-16 (Vivek *et al.*, 2017; Jose *et al.*, 2022). For the compression machine, the loaded level is maintained constant at 0.25 0.05 MPa/s, whereas displacement rate in beam test was kept constant at 0.15 mm/min. The stress-strain measurements were gathered with the aid of a computerized compress meter to compute elastic modulus according to ASTM C469-14 (Bhanu *et al.*, 2022). The values were gathered for test procedure in this investigation (Figure 6). The primary method of flexural testing involves a 28-day test. Curing in a specimen evaluates the amount of pressure needed to bend a plastic beam and establishes a material's stiffness or resistance to flexing. The material's ability to bend before permanently deforming is indicated by its flex modulus.

Figure 3. Compressive strength test

Table 5. Average Compressive strength of M $_{20}$ grade concrete

Sl.No	PP aggregate (%)	Compressive strength at 7 days (N/mm^2)	Compressive strength at 28 days (N/mm^2)
1	0	13.8	19.38
2	5	12.6	16.9
3	10	11.5	17.63
4	15	13.3	18.89
5	20	11.01	17.7

Table 6. Average Flexural Strength (N/mm^2) at 28 days of M20 Grade Concrete

Sl.No	PP aggregate (%)	Flexural strength at 7 days N/mm^2	Flexural strength at 28 days N/mm^2
1	0	3.3	7.3
2	5	5	6.3
3	10	4.99	6.89
4	15	4.80	7.89
5	20	2.3	5.9

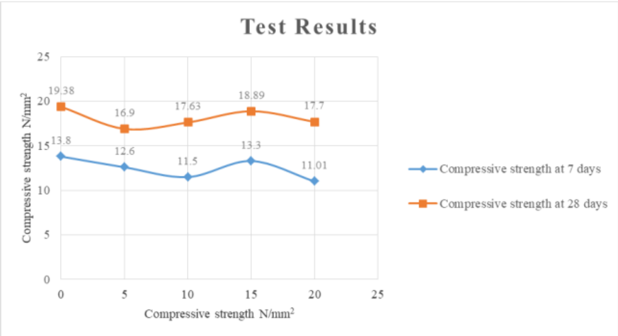

Figure 4. Strength results of Compression test

Figure 5. Flexural strength test

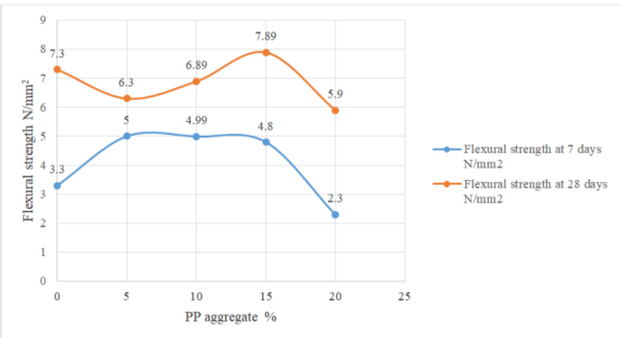

Figure 6. Strength results of Flexural test

Essentially, waste plastic may become a long-term additive and relative replacement substitute for traditional modern building material twin challenge with managing polymer trash while also assisting in the lowering of the construction industry's environmental footprint. However, there is still a long way to go before the notion can be commercialized. More research is needed to completely comprehend the qualitative and quantitative polymer sludge building has both benefits and drawbacks of materials. The following are some of the difficulties that must been resolved during additional investigation as well as development:

- Plastic waste in optimal quantities as an element of construction materials is required.
- Methods for sanitizing plastic trash those are both safe and effective in removing potential pollutants.
- A life cycle of carbon analysis should substantiate its assumption of long-term viability.
- An assessment of the additional expense of industrial manufacture at this building development product.
- The research showed that 15% is the best substitute for coarse gravel in terms of compressive and flexural strength and durability, hence PPA can be used as a partial replacement for coarse aggregate in concrete.
- Using PPA as a partial replacement of 15% in concrete can provide test results at 28 days of curing that are superior to those obtained using a nominal concrete mix (Tables 5 and 6).

5. Conclusion

The following conclusions are drawn from the use of concrete mixtures with 0, 5, 10, 15, and 20% PPA replacement:

- PPC provided significantly improved workability than conventional concrete aggregate while maintaining the same w/c ratio. Due to this, it is possible to achieve the appropriate concrete strength while working with low w/c ratios.

- With PPA, high strength concrete is possible, particularly for concrete with a low w/c ratio and little PPA replacement. At a w/c ratio of 0.45 and 15% PPA replacement, 18.89 MPa compressive strength was attained. PPA can be used with confidence for structural concrete because of its great workability, which makes it easy to include low w/c ratios into concrete mix designs.
- PPA had a flat surface, which led to a poor connection between the PPA and cement matrix. PPA's surface may be roughened through surface modification or chemical treatment, improving bonding. Additionally, limiting the PPA substitution by 15% would guarantee comparable compressive strength to the normative concrete.

Research findings

The primary goals of these findings are to avoid environmental contamination, provide value to industrial materials, and limit plastic shrinkage, drying shrinkage, and cracking while also boosting durability. Additionally, to do research on building materials based on concrete's PPA durability qualities and also on the basis of recycled water.

In the future, exploring the use of PPA in different types of concrete and construction applications, such as precast concrete, self-consolidating concrete, and high-performance concrete can be studied.

Declaration

Ethics Approval and Consent to Participate

No participation of humans takes place in this implementation process

Human and Animal Rights

No violation of Human and Animal Rights is involved.

Funding

No funding is involved in this work.

Conflict of Interest

Conflict of Interest is not applicable in this work.

Authorship contributions

There is no authorship contribution.

Acknowledgement:

There is no acknowledgement involved in this work.

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