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Polyethylene Terephthalate (PET) Waste as Partial Aggregate and Reinforcement in Reinforced Concrete: A Review

Renz Brixter B. Lingamen[1,2], Orlean G. Dela Cruz[1*]

[1]Graduate School,
Polytechnic University of the Philippines, Manila 1016, PHILIPPINES

[2]Philkoei International Inc., San Antonio, Pasig 1600, PHILIPPINES

*Corresponding Author

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Abstract: Plastic disposal is now a significant problem for the sustainability of the environment. And, viewing the engineering properties of plastics (e.g., lightweight, flexible, strong, moisture-resistant, and cheap) opens the possibility of using them as a structural material. Over the decade, many researchers have studied using plastics as a replacement for natural aggregates in concrete or as an additive. Besides, past experimental results have shown that adding plastic waste in concrete will alter the concrete's mechanical and durability properties. However, such concrete can still fulfill engineering properties and be used in other structures with low strength requirements. This research intends to try other possibilities of using plastic waste as partial aggregate and reinforcement in reinforced concrete. Therefore, it is proposed that researchers look into the effects of plastic particles in concrete on the environment and their durability over time due to its deterioration. It recommends surface treatment of plastics waste using appropriate chemicals.

Keywords: Polyethylene Terephthalate (PET), waste materials, partial aggregates, reinforcement, reinforced concrete

1. Introduction

For about 50 years (1964~2014), the rapidly growing plastic industry brought a wide range of benefits to society globally. However, due to rapid urbanization, the demand for plastic products increased dramatically, and with this high demand for plastic production. Therefore, mismanaging different types of plastic waste is a consequence that significantly affects the economy and the environment [1]. Yearly, the global economy loses around USD 80~20 billion worth of plastic packaging because of addressing recycling inappropriately. In addition, around 4.8~12.7 million tons of plastic waste leak into the ocean each year, and 80.0% of this waste comes from Asia, with China being number one, followed by Indonesia, with the Philippines as the third-largest contributor with an estimated value of 0.75 million metric tons of waste plastics entering the ocean [2]. However, the increase in plastic waste can be reduced by recycling and incorporating them into construction materials. Also, a significant challenge for recycling PET plastic waste would be the food waste and the paper fractions left on the plastic, making its recycling process complex [3].

Moreover, PET is a type of rising garbage that might shortly lead to a landfill shortage. Thus, replacing concrete aggregates with PET can address or eliminate such a problem while preserving the natural environment [4] and using PET fibers as concrete reinforcement to increase its tensile strength [5]. Furthermore, considering the intrinsic behavior of plastics (e.g., surface roughness, shape, and low fire resistance), the effects of it can vary due to the preparation of the materials [6].

Various literature that waste materials like PET can alter the mechanical properties of concrete [7]; however, if a study has advanced to a point where waste material like PET can now use for structural purposes, it can benefit the

*Corresponding author: ogdelacruz@pup.edu.ph

community from an environmental standpoint. Therefore, the author reviews the different studies conducted using PET plastic wastes on concrete to confirm various information (e.g., recycling methods, mechanical properties of concrete with waste plastics involved in the mixture, and the used optimum ratio of plastics).

2. Polyethylene Terephthalate (PET)

2.1 History of Polyethylene Terephthalate (PET)

It was the year 1941 when Du Pont chemists developed it while experimenting with polymers to make textiles—manufacturing PET from the synthesis of terephthalic acid and ethylene glycol. As a result, PET has high strength and durability even though it is lightweight and processed without additives. Because of this, it requires less material for packaging components and plastic film.

2.1.1 Characteristics of Polyethylene Terephthalate

Listed below are the most significant properties of PET:

- Transparency: PET is a naturally see-through substance.
- Strength to Weight Ratio: PET is surprisingly robust for its weight.
- Shatterproof: PET is highly dimensional since it does not fracture or shatter.
- Chemical Resistance: PET does not react with water, food, or other chemicals, making it suitable for consumable packaging.

2.1.2 Recycling Methods of PET as a Constituent for Concrete

When it comes to concrete, recycling methods of PET are commonly done by using the recycled material as an aggregate or informs of fibers that aim to improve the tensile strength of concrete and other cement-based products. Fig. 1 shows the number of related studies using PET on concrete published yearly; the data collection using Scopus.

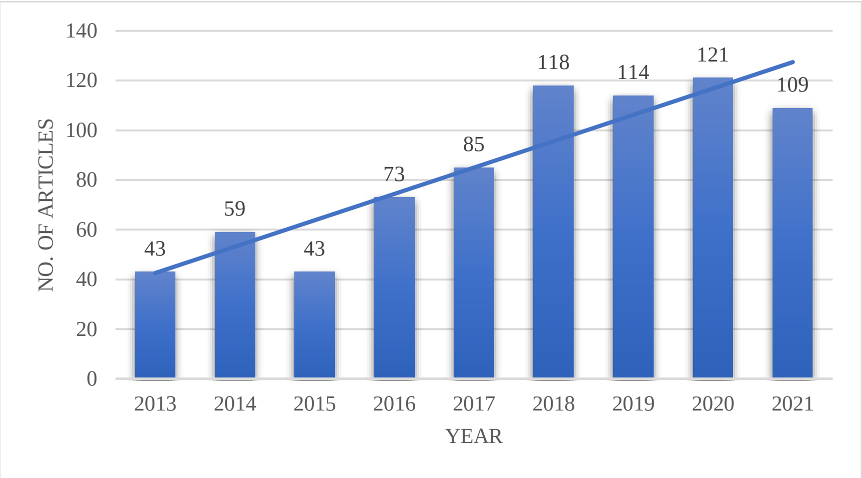


Fig. 1 - Published articles per year using PET plastics in concrete

In various research on PET in concrete, the material was used either as an aggregate (fine or coarse) to replace natural aggregates or synthetic fiber. Table 1 shows past studies by other researchers that most PET recycled wastes are cut and employed in concrete as fiber.

3. Effects of PET On Engineering Properties of Concrete

3.1 Fresh Properties of Concrete with PET

Concrete remains fresh until its setting time (24 to 48 hours). Therefore, fresh concrete expected to give the best results must achieve good workability. Segregation must not happen on fresh concrete upon placing the mixture since its hardened properties depend highly on its new properties due to its consistency gradually decreasing over time. When using waste plastics as a partial replacement for natural coarse and fine concrete aggregates, the altered new property depends on the replacement amount and the material preparation's nature.

Table 1 - Types of recycling methods and target materials in the literature

Year	Reference	Origin of Plastic Waste	Recycling Method	Testing Employed	Target Material
2010	[8]	Waste PET bottles	Griding	C, T	Fine Aggregates
2013	[9]	Milling textiles, Grocery bags, Detergent bottles	Pulverizing	C	Fine Aggregates
2014	[10]	Refreshing drinks, Water, Tea, and Juice bottles	Cutting (Continuous)	C, F	Fibers
2014	[11]	Recycled plastics	Plastic Flakes	C, F[a]	Coarse Aggregates
2015	[12]	Donated (Not waste)	Melt impregnation compression moulding, cutting	T, F	Fibers
2015	[13]	Waste PET bottles	Cutting, Mechanical Slitting	F	Fibers
2015	[14]	Pet bottles	Shredding (Flakes)	C, S	Coarse Aggregates
2016	[15]	Recycled bottles	Shredding	P, C, F	Fibers
2016	[16]	Plastic wastes	Plastic Fragment	U, C, F, B	Coarse & Fine Aggregates
2017	[17]	Bottles found in the trash	Shredding	C, T	Fibers
2018	[18]	Waste PET bottles	Cutting (Ring Shaped, Granules)	C, T	Fibers
2019	[19]	Plastic food and bottle containers	Crushing	F	Coarse Aggregates
2019	[20]	PET bottle wastes	Cutting	C, F[b]	Fibers
2019	[21]	PET bottle wastes	Cutting	C, F	Fibers
2020	[22]	Waste Containers	Cutting	C, S	Fibers
2020	[23]	Drinking water bottles	Cutting	F, C, T	Fibers
2020	[24]	Plastic beverages	Shredding	F.T., S.F., C, F, T	Fibers
2020	[25]	PET bottles	Cutting	C, UT, P, F	Fibers
2020	[26]	-	PET Chips	S, C, T.H.	Coarse Aggregates
2021	[27]	PET bottles	Cutting	C, S, F, T	Fibers

Note: C – Compressive Strength Test; F – Flexural Strength Test; T – Tensile Strength Test; P – Pull-out Test; U – Ultrasonic Pulse Velocity Test; B – Brazilian Test; F.T. – Flow Table Test; S.F. – Slump Flow Test; UT – Uniaxial Tension Test; T.H. – Thermal; F[a] – Four Point Bending Test; F[b] – Three Point Bending Test

3.1.1 Workability of Concrete with PET

The Concrete Slump Test is the common field practice of determining the workability of fresh concrete mix. There are at least nine factors affecting the slump of fresh concrete: (a) aggregates' shape, (b) aggregate' size, (c) aggregates' surface texture, (d) aggregates' grading, (e) concrete's mix proportion, (f) concrete's water content, (g) concrete's cement content, (h) use of supplementary cementitious material, and (i) use of admixture in concrete.

Various researchers conducted studies on the performance of PET wastes as an aggregate (fine or coarse) and as a synthetic fiber on fresh concrete. Research findings discovered conflicting results, with the majority showing that with an increase in PET waste, the workability of concrete declines., except [28] in which, based on the results of their study, the workability increases proportionately with the increase of PET due to the loss of internal friction between mortar and surface of PET. Another researcher attributed the decrease in the workability of concrete due to the low water absorption of PET compared to cement aggregate [29]. Also, a study [27] found that concrete mixed with the highest amount of PET fiber with an aspect ratio (of 10.0 kg/m^3 and aspect ratio of 110) demonstrated the best slump and attribution of PET fibers to the lower rigidity [25].

3.1.2 Density of Concrete with PET

Concrete compositions' specific gravity and compactness are excellent for producing high-density concrete. On the other hand, plastics are lightweight compared to natural aggregates, producing lower-density concrete. The decrease in density is directly proportional to the amount of PET [9] [14] [16] [19] [27]. Therefore, using plastic as fiber or aggregate reduces workability and density, and the shrinkage property of the concrete increases due to the low stiffness of plastic aggregates [7].

3.2 Mechanical Properties of Concrete with PET

In concrete or cementitious materials, mechanical properties are essential if the materials are suitable or practical for the construction industry. This section aims to outline the mechanical properties of concrete with PET published in the literature.

3.2.1 Elastic Modulus

Relative to the findings of the compressive strength of concrete employed with PET, the elastic modulus reduced significantly with the increasing amount of PET in a concrete mixture [16] [30]. The concrete's low elastic modulus is due to PET's low elastic modulus. The findings state that a composite material's elastic property depends mainly on the elastic properties of the constituents' materials and their amounts [31]. Furthermore, other studies using PET and different waste plastics had the same results. The elastic modulus decreased but is lower [32] [33]. In addition to the changes in elastic modulus, one study gets a result with a significant change in Poisson's ratio of the concrete. Compared to the reference concrete with the resulting Poisson's ratio of 0.195, concrete containing waste plastics yield a ratio of 0.25 [34].

3.2.2 Compressive Strength

In using PET as an aggregate or fiber, results for the optimum amount of PET in concrete varies between studies of different researchers. The only thing that is the same in these studies is that the compressive strength of concrete decreases when the usage is beyond the optimum amount. The drop in compressive strength is that the PET particles mixed within the cement paste are softer than the fine natural aggregates. Therefore, when the compression force is applied, cracks start forming in the surrounding cement paste, weakening compressive strength [35]. Table 2 shows the findings of the compressive strength of concrete mixed with various amounts of PET.

Table 2 - Compressive strength test results in the literature

No.	Year	Reference	Material	Amount of PET	f'c (Mpa) w/o PET	f'c (Mpa) w/ PET
1	2012	[36]	Fiber	0.30%	29.00	29.52
2	2015	[37]	Fiber,	0.50%	25.00	24.33
			Flat End Fiber	0.50%	25.00	25.46
3	2016	[38]	Flakes	10.00%	15.00	16.56
4	2017	[39]	Fiber	10.00%	30.00	31.00
			Flake	10.00%	30.00	31.00
5	2017	[40]	Fiber	1.00%	35.00	42.70
6	2018	[41]	Pulverized	8.00%	25.00	29.42
7	2019	[42]	Fiber	0.25%	55.00	47.85
8	2020	[43]	Flakes	25.00%	18.32	14.00
9	2020	[44]	Fiber	1.00%	40.00	36.08
10	2020	[45]	Pulverized	7.50%	35.00	50.27

3.2.3 Flexural and Tensile Strength

Incorporating PET into the concrete mixture affects Tte concrete's flexural, tensile, and fracture properties. From most of the studies conducted, it is evident that there is a gradual decrease in flexural/tensile strength with an increasing amount of PET used in concrete. There is a study where PVC plastic was used instead of PET. This study revealed that for samples containing 20.0% of PVC, the poor quality of the concrete surface is noticeable. The surface of the concrete sample crumbled because of poor strength [46], and the same factors affect the compressive strength of the concrete. Although, in most cases, the flexural/tensile strength of concrete reduces due to the incorporation of plastics in the mixture, one study reported that by moderately adding plastics to the concrete mixture for about 15.0% (Optimum amount), there could be an increase in flexural/tensile strength [34]. Also, by reducing the water-cement ratio of the concrete mix, the reduction in flexural /tensile strength can be lowered [47]. As stated previously, poor surface quality (bonding of cement and plastic) results in lower strength of the concrete.

Therefore, to achieve better performance in using plastics, surface treatment could be helpful to enhance the bond between cement and the constituent plastic material [19]. Fig. 2 shows an image captured after the debonded plastic from the cement paste upon reaching ultimate strength.

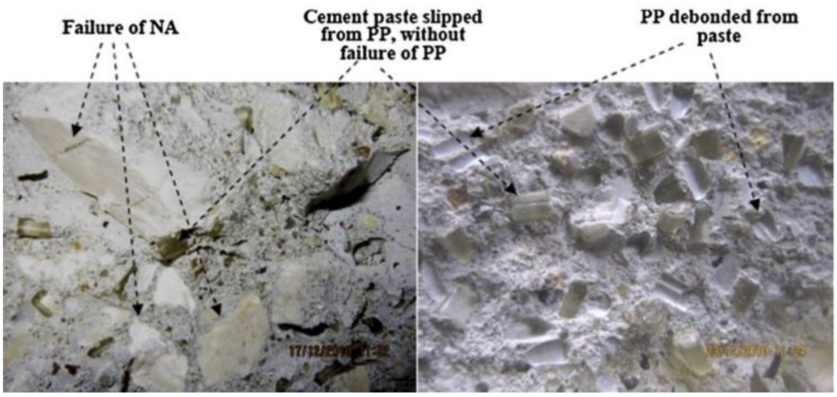


Fig. 2 - Photo of the concrete specimen after failure in the tensile splitting test [48]

3.2.4 Ultrasonic Pulse Velocity

The Ultrasonic pulse velocity (UPV) test is an in-place non-destructive test to check the quality of concrete and natural rocks. Testing measures the time taken using an ultrasonic pulse through the structure; higher velocities mean that the concrete is of good quality and homogeneity, and the slower value indicates the possibility of concrete cracks or voids. From the theory of sound propagation in solids, the transmission of sound velocity depends on the density, elastic modulus, and agitation on concrete caused by excitation frequency. Aggregates, one of the significant aspects that are generally rigid and the part of concrete that is resistant, influence this correlation and change the elastic properties of concrete [49]. For example, one study reported that with an increasing amount of PET and observed the reduction of ultrasonic pulse velocity. The addition of plastic particles in the mix makes the concrete more porous, therefore, obtaining a lower pulse velocity with a higher amount of PET [50]. Figure 3 below shows the Ultrasonic pulse velocity test result for a sample with different water-cement ratios.

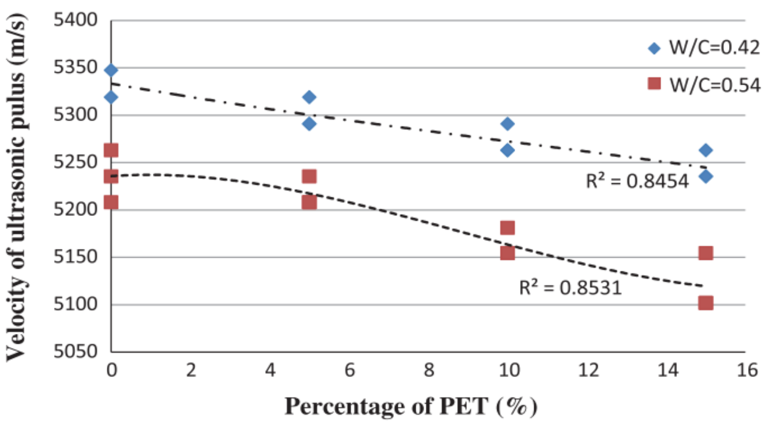


Fig. 3 - Result of Ultrasonic pulse velocity at 28 days with different water-cement ratios [50]

To the book "Concrete Technology," ultrasonic pulse velocity of good quality ranges from 4100 to 4700 m/s [51]. Therefore, the mechanical properties of concrete are affected negatively by using plastic waste as aggregates or fiber. However, considering many parameters, such as the type of plastic waste, size, shape, and especially the microstructure of concrete, has not been studied adequately to observe the bond strength between concrete and plastic constituent. Therefore, more research is required to classify the uses of a specific number of plastic wastes in concrete.

4. Durability of Concrete with PET

Durability is a material's or structure's capacity to endure in a service environment for a specified amount of time without requiring major repairs or rehabilitation [52]. Most buildings have a design service life of 30 years or more, although they can endure 50 to 100 years or longer. Because of their durability, most concrete and masonry structures are demolished, owning to functional obsolescence rather than deterioration. Therefore, selecting materials for concrete mixing is essential for developing good structure durability. According to the previous study, recycled plastic aggregates are less durable than natural aggregates. However, some investigations have shown that [6].

4.1 Shrinkage

When the moisture content in the concrete is insufficient, it shrinks. Shrinkage can occur during the curing process or after the concrete has hardened. Plastic shrinkage occurs when the situation arises during the setting process, and after setting the concrete, it shrinks as it dries (Drying Shrinkage). Table 3 shows the testing results conducted for drying concrete shrinkage per mix.

Table 3 - Results of drying shrinkage per mix [53]

Mix	Amount of PET	Fine Aggregates	GBFS	Drying Shrinkage			
				7 Days	14 Days	28 Days	180 Days
1	25.64%	-	-	0.10%	0.14%	0.17%	0.25%
2	25.64%	-	25.64%	0.12%	0.15%	0.17%	0.25%
3	16.95%	33.90%	-	0.08%	0.11%	0.21%	0.16%
4	16.95%	33.90%	16.95%	0.08%	0.10%	0.11%	0.15%

In addition, the long-term shrinkage of concrete with fine PET aggregates shows that less than 3.0% is the recorded highest shrinkage value found in concrete with 5.0% PET aggregates mixed in concrete [8]. In 2011, [54] reported that the inclusion of plastic aggregates resulted in a reduction in drying shrinkage; this happened due to the impermeable nature of plastic aggregates, that less water is absorbed and allowing more free water to hydrate the cement, resulting in reduced shrinkage values. It is also worth mentioning that while an increase in free shrinkage is because of the recycled waste plastic addition, it appears that the same addition also reduces restrained shrinkage cracking.

4.2 Water Absorption and Porosity

Concrete's serviceability is determined by its durability. Furthermore, the capacity of a fluid to enter the microstructure of concrete, known as permeability, is crucial to its longevity. It is reported that the curing conditions highly influence concrete's water absorption; the concrete exposed to air curing ($20 \pm 3^\circ$C, R.H. $90 \pm 5.0\%$) demonstrated minimal water absorption based on the curing parameters in this study [55]. Therefore, many researchers studied and investigated the water absorption and porosity of concrete with plastic aggregates to evaluate its properties and if it can resist the corrosion of steel reinforcement. As the amount of plastic in concrete increases, the water absorption also increases, and in comparison, to the reference concrete, the mix with 15.0% coarse plastics has about 100.0% greater water absorption [56]. In a study, plastic aggregates as a replacement for fine aggregates by volume (10.0%, 25.0%, and 50.0%) in concrete production, and the exact amount of water absorption is around 10.0% plastic aggregates. However, this trend did not happen for a high volume of plastic aggregates; in the case of 50.0%, the water absorption is 117.0% higher than reference concrete [57].

In research by Vaillancourt et al. [32], they found no clear link between the amount of plastic aggregate and water absorption. Surprisingly, the mix with the most significant air-void percentage had the lowest water absorption in their research. It is due to adding admixtures (air-reducing surfactants) in some of the mixes, which might have reduced the hydrophobicity of the waste plastic aggregate.

4.3 Resistance to Chemical

4.3.1 Chloride Ingress

Chloride penetration is one of the most common causes of corrosion in reinforced concrete (R.C.) constructions, resulting in premature deterioration. Chloride infiltration mechanisms, and therefore the operational service life and safety of R.C. structures, are directly affected by weather and exposure conditions. As a result, comprehensive chloride ingress models are valuable tools for estimating corrosion start risks and lowering maintenance costs for R.C. Structures exposed to chloride. Chloride penetration in concrete is a complicated process triggered by several factors [58].

- The concentration of chloride in the surrounding environment changes throughout time.

- The quantity of chloride in contact with concrete by its environmental exposure is in four categories: submerged, tidal, splash, and salt spray.
- Environmental factors (e.g., temperature and relative humidity) impact material quality over time.

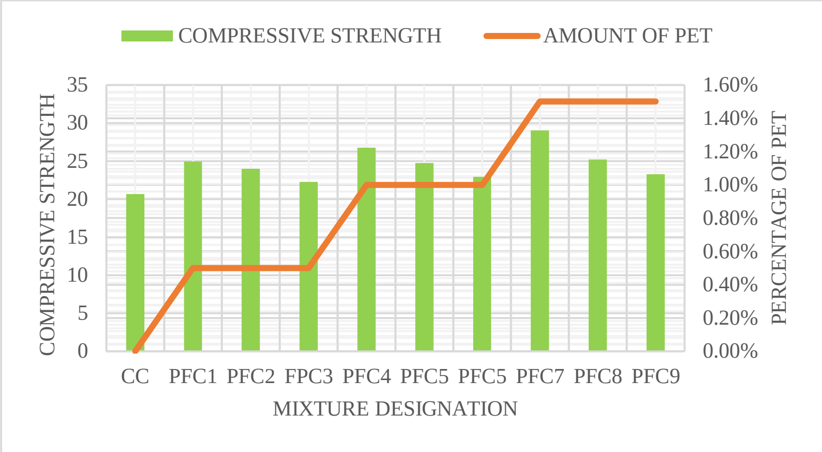


Fig. 4 - Loss of compressive strength after 90 days of curing under chloride [59]

As a result, resistance to chloride intrusion is one of the most significant indications for evaluating concrete durability. However, studies on the resilience of concrete, including recovered waste plastics, to chloride infiltration have yielded mixed findings. One study finds out that the inclusion of plastic in concrete enhances its resistance to chloride intrusion due to the impermeable nature of plastic, which obstructs or diverts chloride ion transport [60]. It is worth noting that, according to ASTM C1202, if the charge (in coulombs) in a rapid chloride permeability test (RCPT) of concrete exceeds 4000, the resistance to chloride intrusion is considered low. A study conducted by Krishnamoorthy et al. [59] yielded results that agreed with Alqahtani et al. [60] regarding the enhancement of chloride resistance of concrete upon the inclusion of plastic as an aggregate in the concrete mixture. Figure 4 below shows the loss of compressive strength of the sample after 90 days of curing in chloride, and Figure 5 shows the chloride permeability reading for the sample mixes [59].

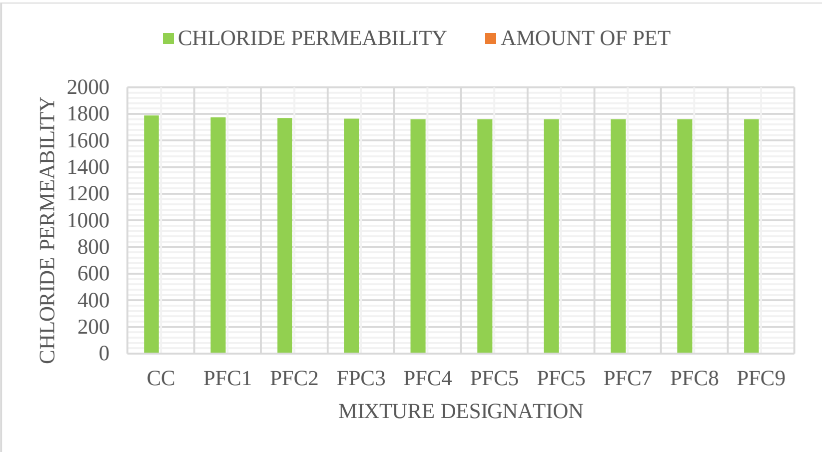


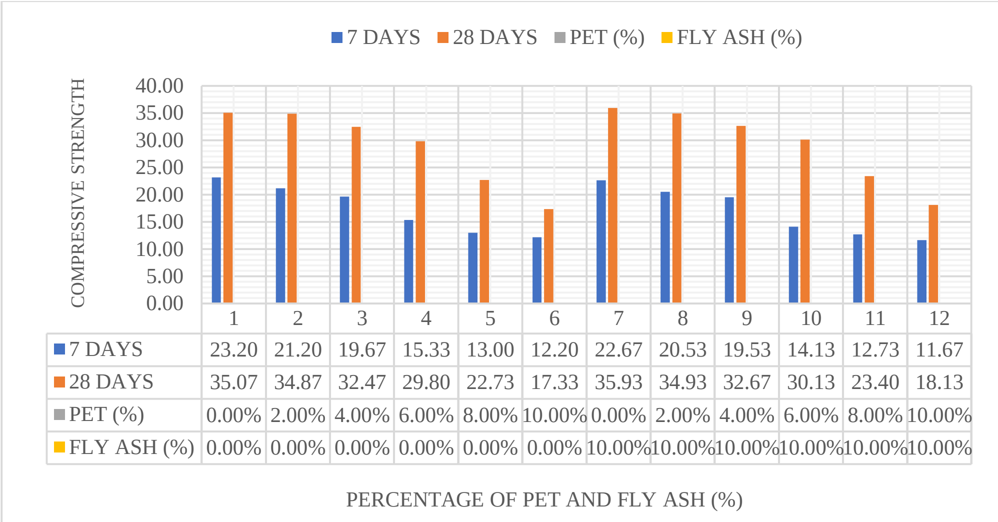
Fig. 5 - Chloride permeability reading for the sample mixes with plastic [59]

5. Other Materials for Modification of Concrete

Concrete is a widely used construction material in the construction industry. Concrete offers incredible strength, structural stability, and durability and especially comes at in low cost compared to other construction materials available in the industry. Recalling the previous chapter's discussion, PET or plastic wastes in concrete has various effects on its mechanical characteristics. Most of the findings imply that just a tiny amount of PET can be added to concrete to avoid too many changes in its characteristics. As a result, numerous studies have employed different forms of waste as supplementary ingredients of concrete and PET to improve concrete characteristics and effectively recycle waste.

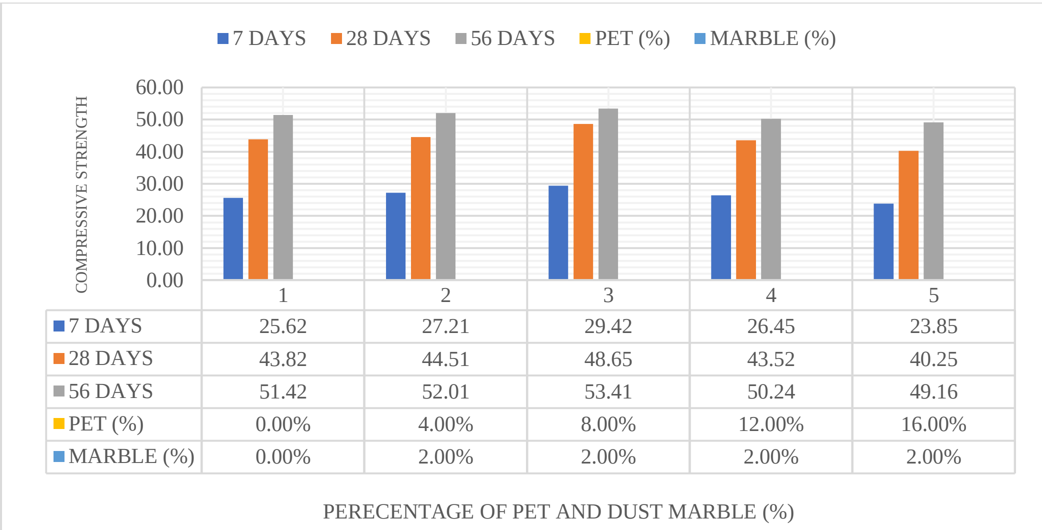
5.1 Use of Fly Ash in Concrete with PET Aggregates

Due to pozzolanic reactions of fly ash, concrete with a regulated amount of 30.0% to 40.0% has its compressive strength increased progressively up to 180 days [61]. The alkali binding and interconnecting reduction voids associated with fly ash concrete are the highlight contributing to concrete's enhanced drying shrinkage and chloride permeability. On the other hand, another research conducted [62] suggests that the compressive strength of concrete decreases due to the inclusion of plastics by using fly ash up to 10.0%. Table 6 shows the compressive strength of samples with both PET and fly ash.



	1	2	3	4	5	6	7	8	9	10	11	12
7 DAYS	23.20	21.20	19.67	15.33	13.00	12.20	22.67	20.53	19.53	14.13	12.73	11.67
28 DAYS	35.07	34.87	32.47	29.80	22.73	17.33	35.93	34.93	32.67	30.13	23.40	18.13
PET (%)	0.00%	2.00%	4.00%	6.00%	8.00%	10.00%	0.00%	2.00%	4.00%	6.00%	8.00%	10.00%
FLY ASH (%)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	10.00%	10.00%	10.00%	10.00%	10.00%	10.00%

Fig. 6 - Compressive strength of samples with PET and fly ash [62]



	1	2	3	4	5
7 DAYS	25.62	27.21	29.42	26.45	23.85
28 DAYS	43.82	44.51	48.65	43.52	40.25
56 DAYS	51.42	52.01	53.41	50.24	49.16
PET (%)	0.00%	4.00%	8.00%	12.00%	16.00%
MARBLE (%)	0.00%	2.00%	2.00%	2.00%	2.00%

Fig. 7 - Compressive strength of samples with PET and dust marble

5.2 Use of Dust Marble with PET Aggregates

When using dust marble on concrete, the workability of the fresh concrete diminishes. The amount of water required in concrete increases with the increasing amount of dust marble; as a result, with the water remaining constant, the workability has reduced. The quantity of binder in concrete made by substituting cement with waste marble powder (WMP) decreases as the amount of dust marble rises, substantially reducing compressive strength. WMP has no pozzolanic impact on the concrete's initial and subsequent ages of compressive strength because it is an inert substance. As the amount of dust marble grows, so does the compressive strength, up to a point, after which strength declines [63]. Another research conducted by [41] reports that expansions of marble residue improve the quality of PET concrete. The most exceptional enhancement for compressive, split elastic, and flexural quality testing at 8.0% augmentation with 2.0% expansion of marble dust as an additional substance to each sample. Table 7 shows the compressive strength of samples with both PET and dust marble.

5.3 Use of Granulated Blast Furnace Slag with PET Aggregates

Two curative remedies, one for normal circumstances and the other for salty water; the optimal amount of granulated blast surface slag (GBFS) for the first option is 40.0%, while the optimum amount for the second option varies from 50.0% to 60.0% [64]. Furthermore, a study [65] found that using slag as an aggregate in pavements, precast and prestressed units, foundations, curbs, and gutters, among other concrete structures in road building.

Slag cement for concrete pavement reduces concrete workability compared to conventional cement concrete. It influences a drop in total air content in the mix, resulting in a reduced slump and increased compressive strength, modulus of rupture, and modulus of elasticity, with less shrinkage. Fig. 8 shows the compressive strength of concrete with granulated blast furnace slag with PET aggregates.

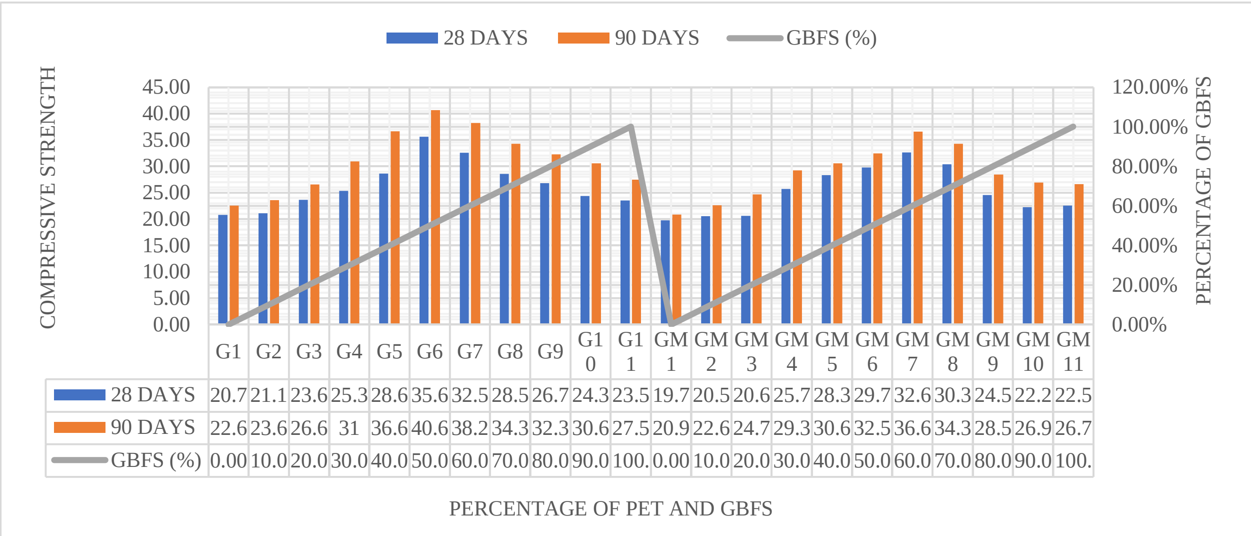


Fig. 8 - Compressive strength of samples with PET and GBFS [64]

6. Challenges of PET Waste in Concrete

Until now, disposing of and recycling waste plastic has been challenging worldwide. As each country's population rises, so does the need for plastic manufacture and consumption. The pollution created by these wastes has already caused harm to our ecosystem, and the primary motivation for pursuing research into feasible plastic recycling processes is to address the growing problem of pollution caused by mismanaged plastic trash. According to the findings of earlier studies, the use of plastics to substitute aggregates has an ideal limit before the mechanical characteristics of concrete deteriorate, owing to the lower strength of plastics compared to natural aggregates. However, some research shows that pre-treating plastic trash before combining it with concrete might improve the strength of the plastics, resulting in significantly enhanced concrete mechanical characteristics [19].

Table 4 - Challenges for recycling plastic waste

Reference	Challenges
[14], [16], [27], [9], [19], [30] [31]-[33]	Lower Density of PET compared to natural aggregates, which also results in low elastic modulus and lower compressive strength of concrete
[35], [46], [19]	Surface preparation of PET Plastic wastes to aid its softer surface
[36], [37], [45],	Conflicting results in mechanical testing (compressive and flexural)
[56], [57], [32]	Conflicting results in water absorption test and its connection to the amount of PET added to the concrete
[60], [59]	Chloride penetration test on concrete with PET
[34]	Lack of data regarding the enhancement of poisons' ratio of concrete
[36]	Degradation of PET plastics in long-term duration

Furthermore, research provides contradictory results regarding concrete compressive strength, modulus of elasticity, and other factors. Although adding a small quantity of plastic trash to concrete improves its characteristics, more study is needed since this material has not been employed in the building sector owing to a lack of information about other factors. Furthermore, according to [36], the polymers included in the concrete deteriorated after 150 days. More study on this subject is required to investigate additional characteristics of concrete before putting it to practical use. Table 4 shows the recommended challenges for the scope of future researchers to update or upgrade the existing studies.

7. Conclusions

Developing renewable materials can determine whether plastic waste improves concrete corrosion resistance and an efficient recycling method for unmanaged plastic waste. However, a more thorough investigation into plastic waste as an addition or substitute for natural aggregates in concrete is needed to understand better how plastic waste can be helpful when used in structural concrete members. Because of its inherent non-reactive nature, plastic waste impacts the mechanical properties of concrete. According to some studies, poor performance is due to the weak bonding of plastic wastes with cement and natural aggregate. In addition, the concept arose from the non-porous properties of plastics with the right amount and with proper study preparation and execution. Despite the adverse effects of using plastic waste in concrete, studies have shown that adequately examining the size or shape (aspect ratio or grading), applying chemical surface treatments, and establishing a proper mix ratio of plastic waste in the mixture can improve concrete performance. Besides, it prevents the plastics from forming a failure surface in the mix. Therefore, plastic wastes with a rough surface, irregular shape, and small size performed better [66]. Therefore, researchers suggested considering plastic aggregates' environmental effects and service lives. Future studies led to the development of renewable materials, which helps address environmental concerns related to plastic waste. Moreover, to advance and develop an effective strategy for utilizing plastic waste in concrete. It also aids in the recycling of our planet's out-of-control plastic waste.

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