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Experimental Study on Partially Replacing Aggregates with Polyethylene Waste in Concrete Pavement

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ABSTRACT- The management of waste plastics presents a significant difficulty in both India and globally due to the escalating consumption of plastics and their extensive decomposition time, spanning many centuries. Therefore, it is imperative to employ efficient strategies for the utilisation of these plastic materials. The primary aim of this study was to examine the viability of utilising waste polyethylene waste (PEW) as a partial substitute for aggregates in the manufacturing of concrete pavement mixtures. This study utilised cement, sand, coarse aggregate, and polyethylene waste (PEW). PEW was utilised as a substitute for aggregates by volume at several percentages, namely 0%, 10%, 20%, and 30%. The findings of the study indicate that the substitution of 5% of the coarse aggregate with PEW waste resulted in an 11% increase in the 28-day splitting tensile strength of the concrete pavement mix. Furthermore, the compressive and flexural strengths of the concrete mix in question exceeded the minimum compressive and flexural values specified by the concrete mix guide. Based on the findings of the test results, it is advised that the utilisation of PEW exceeding 5% of the coarse aggregate composition in the mixture be employed for the construction of low traffic pavements, rural roads and pavements. The redesigned pavement blocks are deemed to have the potential to make a significant contribution towards the global management of plastic waste.

KEYWORDS- Polyethylene Waste, Mechanical Properties, Aggregates, Concrete Pavement

I. INTRODUCTION

Plastic has emerged as a prevalent environmental concern within the modern era, becoming a prominent category of waste products. The proper management of these plastics poses a significant difficulty due to their non-biodegradable characteristics. The majority of these plastics are disposed of in landfills, resulting in significant negative consequences when incinerated. To address these challenges, some scholars have exerted considerable endeavors to incorporate discarded plastics into concrete compositions. The density of plastic concrete is expected to be lower than that of ordinary concrete due to the comparatively low specific gravity of polymers. According to a study conducted by [1], it was observed that there was a drop in the bulk density of plastic concrete with an increase in the plastic component. The density experienced a decrease of around 2.5%, 6%, and 13% when using plastic compositions of 10%, 30%, and 50% respectively. In their study, [2] examined the impact of including discarded PET bottles aggregate on the characteristics of concrete. The incorporation of waste plastic has the potential to decrease the weight of concrete by approximately 2 to 6 percent when compared to conventional weight concrete. In a study conducted by [3] the researchers examined the utilisation of plastic bottles that had been consumed as a substitute for sand. It was observed that the density decreased when the volume of PET aggregate exceeded 50% of the sand volume. According to [4] there was an observed reduction in the weight of concrete with an increase in plastic content. A correlation was observed indicating a linear relationship between the reduction in weight and the increase in plastic content.

Numerous researchers have also documented the advantageous attributes of plastic concrete. The empirical findings indicate that there is a negative correlation between the amount of plastic aggregate used in concrete and its overall strength. According to [5], the inclusion of ground plastic in concrete has been found to have an impact on its compressive strength. The compressive strength exhibited a reduction of approximately 23%, 35%, 50%, and 71% as the fine aggregate was replaced with plastic at proportions of 5%, 10%, 15%, and 20% correspondingly. The study conducted by [6] examined the impact of incorporating post-consumer waste plastic as a soft filler in concrete. The experimental findings indicated a reduced compressive strength in the mixture containing plastic compared to the control mixture devoid of plastic. [2] observed a decrease in compressive strength and splitting tensile strength as well. The compressive strength shown a decrease of 33% in comparison to that of conventional concrete. The splitting tensile strength was shown to decrease with a rise in plastic content, irrespective of the water cement ratio employed [3]. Conducted a study which revealed a decrease in the compressive strength of plastic concrete when plastic was used as a replacement for sand. Similarly, [1] investigated the impact of plastic on concrete mix. A drop in the splitting tensile strength was observed with an increase in the plastic content. According to [5] it was observed that the splitting tensile strength and flexural strength of concrete mix decreased as the plastic content increased. The substitution of plastic for 20% of the aggregate content resulted in a reduction of approximately 56% in the splitting tensile strength. The flexural strength exhibited a reduction of approximately 40% upon the replacement of 15% of the aggregate with plastic.

Plastic fibres encompass a category of synthetic fibres that can exist as either microplastic fibres or macroplastic fibres. Microplastic fibres are defined as plastic fibres with a diameter ranging from 5 to 100 micrometres and a length of 5 to 30 millimetres [7]. According to[8], the utilisation of microfibers has demonstrated efficient control over plastic shrinkage cracking. This type of cracking occurs as a result of the shrinkage of fresh concrete within the initial 24 hours after placement, primarily due to excessive evaporation of bleed water [9]. Nevertheless, according to a study conducted by [10], these additives typically do not have discernible impacts on the characteristics of cured concrete. It is important to mention that certain types of micro plastic fibres, such as nylon fibres, have the ability to effectively store thermal energy in concrete [11]. Additionally, these fibres have the capacity to regulate concrete shrinkage, as well as substantially enhance its tensile strength and toughness. According to [12], macro plastic fibres typically possess a length ranging from 30 to 60 mm and a cross-sectional area of 0.6 to 1 mm2.

Macro plastic fibres are employed not only for the purpose of managing plastic shrinkage, but also primarily for the management of drying shrinkage. Drying shrinkage is a phenomenon that arises as a result of the evaporation of water molecules from the solidified state of concrete [13]. Drying shrinkage of this nature may manifest in expansive, level surfaces such as slabs inside arid and high-temperature regions, as seen by the case of North Queensland, Australia. The utilisation of macro plastic fibres is increasingly replacing steel reinforcing mesh in the prevention of drying shrinkage cracks due to advantages such as simplified building processes, decreased labour requirements, and reduced costs. The macro plastic fibres have been found to offer a notable advantage in terms of post-cracking performance, as highlighted by [14]. Brittle plain concrete lacks significant post-cracking ductility. However, the inclusion of macro plastic fibres can significantly enhance the post-cracking behaviour of concrete. This is due to the crack arresting properties of the plastic fibres, which transform the inherently brittle concrete matrix into a more resilient material with improved crack resistance and ductility. Hence, in the event of concrete fracture, the typical occurrence of big individual cracks might be replaced by the formation of numerous closely spaced micro-cracks as a result of the inclusion of fibre reinforcement. According to [15], there has been a growing trend in utilising macro plastic fibres for the building of concrete pathways, precast parts, and shotcrete mine tunnels.

The feasibility of incorporating recycled concrete in roller-compacted concrete pavement (RCCP) was investigated by [16]. The specific gravity, water absorption, and Los Angeles (L.A.) abrasion of the recycled aggregates were all properly evaluated. The substitution of natural aggregates with recycled aggregates in concrete road construction resulted in a reduction in the compressive strength of Roller Compacted Concrete Pavement (RCCP). In general, the utilisation of recycled aggregates in roller-compacted concrete (RCC) mixtures shown favourable performance characteristics.

The study conducted by [17] examined the impact of curing conditions on the long-term strength and durability of concrete mixes following the substitution of waste plastics, specifically polyethylene terephthalate, as both coarse and fine aggregates. The study found that natural aggregates were replaced by waste plastics with concentrations of 7.5% and 15%. The specimens underwent tests, including shrinkage and water absorption assessments. Ultimately, the findings of the study revealed that the specimens with waste plastic exhibited a decrease in durability when compared to the control specimens.

Based on current research conducted on the utilisation of recycled materials in concrete pavements, it has been determined that Roller-Compacted Concrete Pavement (RCCP) is a viable approach to addressing environmental and ecological concerns. Furthermore, the implementation of RCCP leads to a reduction in construction expenses through the decreased reliance on natural aggregate. The waste generated by cross-linked polyethylene (XLPE) is comprised of non-biodegradable components that exhibit limited fluidity, rendering them unsuitable for remelting and subsequent moulding processes. Currently, the majority of XLPE wastes are either incinerated for fuel or disposed of through burial methods. It is imperative to conduct an investigation into the utilisation of XLPE waste materials as aggregates in the mix of Roller Compacted Concrete Pavement (RCCP) [18] . The tensile strength, ductility, and energy absorption capacity of Roller Compacted Concrete Pavement (RCCP) exhibit comparatively lower values when compared to alternative concrete pavements that incorporate dowels and steel reinforcement. While additional research is required to identify an effective and cost-efficient strategy for recycling XLPE wastes, it appears that utilising these wastes as substitutes for aggregates may offer potential benefits in terms of mitigating environmental concerns and conserving energy resources. Furthermore, due to the low costs or even absence of charges associated with the disposal of these waste materials, there is a resultant decrease in building expenses.

The information presented shows a great attention to the potential use of low density polyethylene waste (PEW) as aggregate in concrete mixes. Therefore, the current research is aimed at investigating the possibility of utilizing PEW as partial replacement for aggregate in the manufacturing of concrete pavement specimens. The use of waste PEW in concrete mix pavement will contribute to providing environmentally friendly solution for the plastic disposal problems in India and the world as a whole.

The primary aims of the current study encompass: -

- The use of PEW as an aggregate in concrete mixtures, specifically as a partial replacement for coarse aggregate, at varying volume percentages.
- This study aims to assess the compressive strength, splitting tensile strength, and flexural strength of concrete pavement through the substitution of polyethylene waste (PEW) with coarse aggregate and cement.

A. Physical properties of polyethylene

Table 3 presents the primary characteristics of several polyethylene variants, which encompass a wide range of types. Polyethylene exhibits varying degrees of crystallization and branching depending on its density. Among the various forms of polyethylene, low density polyethylene (LDPE) is considered a more acceptable option as an asphalt modifier. This is primarily attributed to its lower density and larger molecular spacing. Hence, the infiltration of Saturate and Aromatic compounds into the molecular structure of asphalt facilitates the expansion of LDPE by molecular chain penetration. According to [18], LDPE has been found to significantly enhance the mechanical qualities of asphalt binder when compared to other forms of polyethylene. As a result, LDPE is considered a high-quality modifier for asphalt.

B. Materials

The materials utilized in this investigation comprise of Portland cement grade 43, crushed calcareous gravel, and sand. The calcareous gravel and sand were procured from a nearby vendor located on Sirhind Road within the urban area of Patiala. The aggregates were utilized in three different sizes, specifically those that passed through sieve sizes of 3/8 inch, 1/2 inch, and 3/4 inch, corresponding to maximum particle sizes of 10 mm, 14 mm, and 19 mm, respectively. Cement paste was produced using water that did not contain any additives. The PEW were sourced from a supplier located near the focal point in Patiala. The conversion of PEW into the suitable dimensions was accomplished by the utilization of a specialized equipment designed for the recycling of plastic materials. The dimensions of the recycled PEW materials were preserved by the implementation of sieve No. 4, which has a mesh size of 4.75 mm additionally, the materials that successfully passed through sieve 3/8 inch (10 mm) were also accounted for. Figure 2 depicts the dimensions of the PEW granules employed in the investigation. The upper limit for the size of coarse material in the concrete mix gradation was 19 mm. Table 1 presents the physical and chemical parameters of Portland cement. Table 2 presents the physical characteristics of both fine and coarse aggregates.

Table 1: Physical and Chemical Properties of Cement

Physical Properties		Test Result
Fineness (m^2/kg)		312
Initial Setting Time (min)		36
Final Setting Time (min)		390
Specific Gravity		3.12
Chemical Properties		**Test Result**
Calcium Oxide (CaO)		62.30
Silica (SiO_2)		21.05
Alumina (Al_2O_3)		4.17
Iron oxide (Fe_2O_3)		6.05
Magnesia (MgO)		1.62
Alkalies	Na_2O	0.23
	K_2O	0.34
Sulphur Anhydrite (SO_3)		2.56
Total Loss on Ignition		3.39

Table 2: Properties of Fine and Coarse Aggregates

Properties of fine aggregate	
Characteristic	**Value**
Type	Uncrushed (Natural)
Specific Gravity	2.67
Water Absorption	1.03
Finess Modulus	2.503
Grading Zone	III
Properties of coarse aggregate	
Characteristic	**Value**
Type	Crushed
Maximum Size	20 mm
Total Water Absorption	3.630 %
Finess Modulus	7.67
Specific Gravity (20 mm)	2.820

C. Polyethylene Waste (Pew)

The PEW was obtained from street areas and through a drying process before being shredded into smaller pieces. Figure 1 illustrates the utilization of PEW as a binder modifying material. In the preliminary laboratory trials, a mixture was created by combining different contents of PEW based on their respective weights of binder. Given the primary objective of this study was to maximize the utilization of PEW in a concrete mixture, a deliberate endeavor was undertaken to identify the optimal achievable content. Consequently, the aggregates comprising 0%, 10%, 20%, and 30% were substituted with Polyethylene Waste (PEW). Table 3 presents the physical and mechanical properties of polyethylene waste.

(a)

(b)

Figure 1 (a) (b): Polythene Waste and Shredded Polythene Waste in 10mm Pieces

Table 3: Physical and Mechanical Properties of Polyethylene Waste (PEW)

Bulk density (kg/m^3)	543
Specific gravity	1.32
Colour	Transparent white and blue
Melting point (c)	230
Young's modulus (Mpa)	1700–2510
Tensile yield stress (Mpa)	60
Water absorption, 24 hours (%)	<0.01

A total of 72 cylindrical specimens were fabricated for the purpose of conducting compression and split tensile strength tests. Three samples were collected during each curing time, following a methodology akin to flexural beam testing. The height of the cylindrical mould measures 300mm, while its diameter measures 150mm. A total of nine beams, each measuring 100 mm x 100 mm x 500 mm, were manufactured for every replacement. Subsequently, flexural strength tests were performed after 7, 14, and 28 days of the curing process. This study involved the substitution of varying volume percentages (0%, 10%, 20%, and 30%) of aggregate with PEW, where the aggregate had a diameter ranging from 2.36 to 4.75 mm. The PEW utilized in this study consisted of original material due to the unavailability of recycled PET granules (Figure 2). According to [19], it is generally observed that the hardness of recycled PEW granules tends to be higher than that of the original material. In accordance with the designated grading and the dimensions of the PEW granules, a maximum substitution of 15% by weight of the entire control mix was implemented using PET granules. It is important to note that no replacement occurred inside the 2.36–4.75 mm aggregate fraction.

Figure 2: Polyethylene Waste Granules

D. Compressive Strength

The purpose of this test is to ascertain the compressive strength of cylindrical concrete sample. The cylindrical compressive test was conducted using a compression testing machine in accordance with the Indian standard (IS 516-1964), as depicted in Figure 3. The test procedure involves the application of axial force to molded cylindrical specimens at a controlled pace until failure occurs, while ensuring that the loading rate falls within a specified range. The calculation of compressive strength involves dividing the greatest load borne by the specimen during the test by the cross-sectional area of the specimen. The loading rate for the test was 0.3 MPa/s, as specified by the (ASTM) C39, 2011) standard in 2011. The experimental setup involved the utilization of cylindrical specimens measuring 150 mm in diameter and 300 mm in height. The specimens underwent compaction in a manner that involved dividing them into three layers of equal thickness. The compaction of each layer was performed with a top surcharge of 50 g/cm2. In this investigation, a total of 36 cylindrical specimens were manufactured for the purpose of conducting compressive strength tests, irrespective of the test specimens used for mix design determination. Subsequently, the specimens were extracted from the molds after a duration of 24 hours and submerged in standard water for the purpose of curing until they attained the desired test age. The study focused on the mechanical characteristics of the concrete specimens subjected to water curing for durations of 7, 14, and 28 days. The compressive strength test was conducted in accordance with the [20] standard.

Figure 3: Compressive Strength Test Specimen

E. Split Tensile Strength

A cylindrical specimen with a diameter of 150 mm and a depth of 300 mm is utilized. The specimens were exposed to both internal and exterior curing and afterwards tested at intervals of 7, 14, and 28 days. The purpose of this test is to assess the splitting tensile strength of cylindrical concrete specimens, including molded cylinders and drilled cores. The test method involves the application of a diametrical compressive force along the length of a cylindrical concrete specimen at a controlled rate, within a specified range, until failure occurs. When conducting compressive failure tests, it is seen that tensile failure also occurs simultaneously. The splitting tensile strength test shares similarities with the compressive strength test in terms of specimen size, molding, and specimen preparation. A total of 36 primary cylindrical specimens were created for the purpose of this experiment. The preparation technique and the curing conditions employed were analogous to those used for the compressive strength test specimens. Following the completion of the curing period, the specimens underwent the splitting tensile strength test in accordance with the guidelines outlined in the [21] standard.

F. Flexural Strength

The present investigation involved the implementation of a four-point bending test to ascertain the flexural strength of concrete, utilizing a straightforward beam configuration. The outcomes are computed and documented in the form of the modulus of rupture. The measured strength may exhibit variability due to variations in specimen dimensions, preparation methods, moisture content, curing conditions, or the specific location where the beam is formed or cut to the desired size. The specimen's span length, with a tolerance of 2%, should be three times its depth. The testing of specimens cured in water should be promptly undertaken upon their removal from the water curing process. Rectangular beams of 100mm x 100mm x 500mm in length were employed for the purpose of this experiment. A total of 36 rectangular specimens, specifically in the shape of beams, were constructed for the purpose of this experiment. The specimens were prepared using a vibrating table equipped with a surcharge. The specimens underwent compaction with a top surcharge of 25 g/cm2. After a period of 24 hours, the specimens were removed from the molds and thereafter placed in a container filled with regular water for the purpose of curing. The beams were subjected to water curing for durations of 7, 14, and 28 days to assess their toughened qualities. The flexural strength was determined using the standard [22] [23].

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Figure 4: Flexural Strength Test Specimen

II. RESULTS AND DISCUSSION

In order to assess the strength of concrete in practical building scenarios and its ability to withstand rupture, it is necessary to evaluate the strength of test specimens. The subject under consideration can be examined from the perspectives of flexure, compression, and tension. Each of these tests offers an assessment of strength within the context of a specific testing methodology. The failure of compressed concrete can occur as a result of both crushing and shear failure. Concrete is commonly employed in various structural applications primarily for its ability to withstand compressive stress. The primary material properties of hardened concrete encompass compressive strength, split tensile strength, flexural strength, and variations in replacement percentages of aggregates of PEW. Various tests are performed on specimens, such as flexural strength, cylinder compressive strength, and split tensile strength, using distinct substitution materials and diverse curing durations, with the aim of discerning and contrasting the mechanical properties of the concrete. The average value of the three specimens was determined for all the relevant tests, using the test results. The density and vibration compaction time were determined for each proportion of polyethylene waste (PEW). The density of the concrete exhibited a consistent reduction as the proportion of polyethylene waste (PEW) in the concrete mixture increased. The concept of mixing refers to the act of combining different elements or substances together in order to the specific proportions specified in Table 4.

Table 4: Mix Concrete Proportion

Particulars	Conventional Mix	10%	20%	30%
Cement (kg/m^3)	428.33	428.33	428.33	428.33
Sand (kg/m^3)	662.62	662.62	662.62	662.62
Coarse aggregates (kg/m^3)	1164.60	1048.14	931.68	815.22
PEW (kg/m^3)	0	42.83	85.66	128.50
Water (kg/m^3)	183	183	183	183

A. Compressive Strength

The minimal criterion for compressive strength is applicable to the specific layer in which the concrete pavement is utilized. The findings of the study revealed that, in addition to the 28-day control specimens, only the strength of the 28-day specimens containing 10% of PEW exceeded the minimum acceptable strength threshold. Nevertheless, the specimens containing 10% of PEW exhibited a marginal decrease in compressive strength when compared to the control specimen. The compressive strength exhibited a decrease as the percentage of PEW rose. The mean compressive strength after 28 days exhibited a decline from 29.38 MPa in the control specimen to 13.18 MPa in the specimen including 30% of PEW. The observed decrease in strength may be attributed to less adhesion between PEW and cement mortar in the concrete pavement mixture, as compared to the natural aggregate. Additionally, the specimens with PEW exhibit higher porosity compared to those with natural aggregate, which could contribute to the strength loss. Table 4 displays the mean compressive strength values at 7, 14, and 28 days for various proportions of PEW. Figure 5 displays the mean compressive strength values of the specimens containing varying proportions of PEW. The compressive strength of the concrete pavement was judged to be at its minimum permitted level when using a specimen containing 10% PEW. The compressive strength test was performed using a universal testing equipment.

Table 4: The Average Compressive Strength of Specimens

Mix	**Compressive strength (MPa)**		
	7 d	**14 d**	**28 d**
PEW 0%	21.88	24.74	29.38
PEW 10%	21.4	23.78	28.37
PEW 20%	14.07	15.9	18.19
PEW 30%	9.91	11.49	13.18

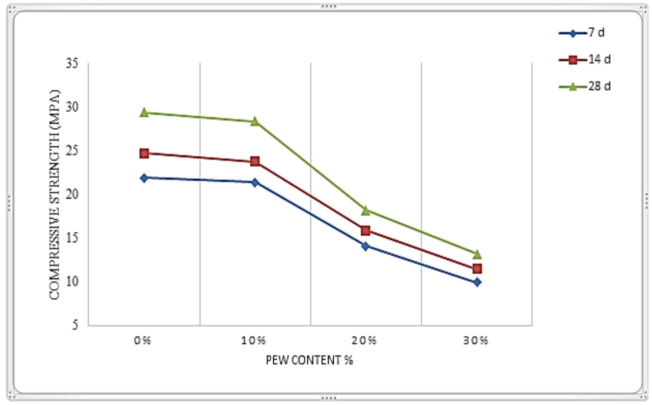

Figure 5: Comparison of Average Compressive Strength of Specimens

B. Split Tensile Strength

The experimental results indicated that the incorporation of 10% PEW led to a noticeable enhancement in the measured splitting tensile strength. In the subsequent analysis, it was shown that an augmentation in the PEW (Polyethylene waste) content had an adverse impact on the splitting tensile strength, resulting in a consistent drop. The splitting tensile strength exhibited a rise from 2.79 MPa in the control specimen at 28 days to 3.12 MPa in the specimen incorporating 10% PEW. The observed 11% increase in performance can perhaps be attributed to the enhanced flexibility of PEW in comparison to natural aggregate, as well as its irregular polygonal shape, which promotes greater interlocking of the aggregate within the concrete mixture. Additionally, it was noted that the rise in PEW content led to a higher likelihood of concrete failure. This can be attributed to the weaker adhesion of PEW compared to natural aggregate, as well as the growing presence of air spaces in the concrete pavement mix. Therefore, the optimal replacement percentage, which resulted in an increase in the splitting tensile strength, was determined to be 10%. Ultimately, the mix that contained 30% of Polyethylene Waste (PEW) exhibited the highest reduction in splitting tensile strength. The pressure reduced to 2.04 MPa. Table 5 presents the mean splitting tensile strength values observed at 7, 14, and 28 days. Figure 6 illustrates the mean splitting tensile strength of the specimens at varying levels of PEW concentration.

Table 5: The average split tensile strength of specimens

MIX	**Splitting tensile strength (MPa)**		
	7 d	**14 d**	**28 d**
PEW 0%	2.29	2.76	2.79
PEW 10%	2.83	3.04	3.12
PEW 20%	2.1	2.27	2.38
PEW 30%	1.89	1.96	2.04

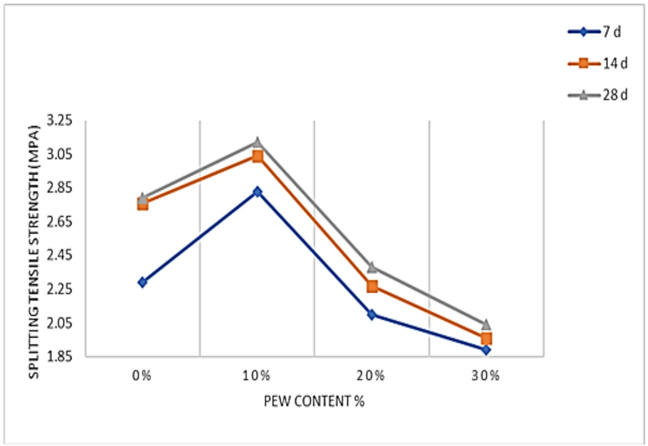

Figure 6: Comparison of the Average Splitting Tensile Strength of Specimens

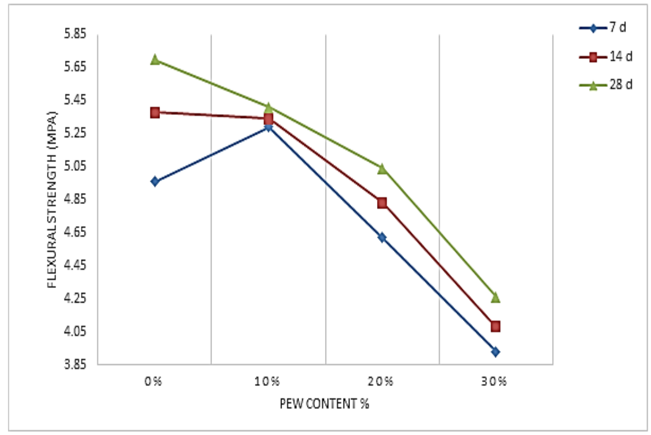

Figure 7: Comparison of the Average Flexural Strength of Specimens

C. Flexural Strength

The results showed greater flexural strength of the 7-d specimens containing 5% of PEW than the 7-d control specimens. In the other specimens, with the increase of PEW content, the flexural strength decreased regularly. This issue might be due to the lower adhesion of PEW compared to the natural aggregate in concrete pavement. Moreover, the replacement of coarse aggregate by PEW might also have increased the air voids of the mixtures. The average flexural strength of the specimens at 7, 14 and 28 days for the different percentages of PEW are presented in Table 6. Figure 7 shows the comparison of the flexural strength of the specimens with different contents of PEW. Figure 4 is related to the flexural strength test by the universal testing machine. The control specimens were broken into two pieces at the time of testing, but the other specimens containing 10%, 20% and 30% of PEW were not separated into two parts. So, the crack in the specimens with PEW was inversely proportional to the percentage of added PEW. This test demonstrates that concrete pavement with PEW waste has higher energy absorption capacity than concrete pavement without PEW. As the PEW content increased, the failure became more ductile.

Table 6: Average Flexural Strength of Specimens

MIX	Flexural strength (MPa)		
	7 d	14 d	28 d
PEW 0%	4.96	5.38	5.7
PEW 10%	5.29	5.34	5.41
PEW 20%	4.62	4.83	5.04
PEW 30%	3.93	4.08	4.26

III. CONCLUSION

This study aimed to examine the utilization of (PEW) as a substitute for natural aggregate in concrete mixtures, exploring different volume percentages. The findings of the study indicated that including PEW as a coarse aggregate resulted in enhancements in some aspects of the concrete pavement:

- When PEW substituted 10% of the coarse aggregate, the compressive strengths of the specimens at 7 days, 14 days, and 28 days fell by 2.2%, 3.8%, and 3.4% correspondingly, in comparison to the control specimens. A decrease in compressive strength was seen for content percentages of 20% and 30%. These percentages may be applicable in some scenarios, including low traffic pavements, rural roads, expansive industrial zones, and pedestrian walkways. The utilization of an optimal proportion of (PEW) is contingent upon the specific technical specifications and objectives of a given project.
- When PEW substituted 10% of the coarse aggregate, the splitting tensile strengths of the specimens at 7 days, 14 days, and 28 days rose by 23.5%, 10%, and 11.82% correspondingly, in comparison to the control specimens. The splitting tensile strengths exhibited a consistent drop as the PEW contents increased for the remaining tested percentages.
- When PEW substituted 10% of the coarse aggregate, the splitting tensile strengths of the specimens at 7 days, 14 days, and 28 days rose by 23.5%, 10%, and 11.82%, respectively, compared to the control specimens. The splitting tensile strengths exhibited a consistent drop as the PEW contents increased for the remaining tested percentages. When 5% of the coarse aggregate was replaced with PEW, there was a 6.2% increase in the flexural strength after 7 days. However, there were minor decreases in the flexural strengths at 14 and 28 days. In relation to the remaining percentages, it was seen that the flexural strength exhibited a consistent decline, while both ductility and cracking resistance demonstrated an upward trend. Utilizing the concept of

Pnature. Recycling them at a minimal cost is a viable method. Furthermore, it concurrently diminishes the necessity for natural aggregates. Ultimately, it is advisable to employ PEW waste as a constituent in the composition of concrete.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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