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Experimental Investigation of Sustainable Concrete Incorporating Waste Polyurethane as a Partial Replacement for Cement

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ABSTRACT

The increasing generation and improper disposal of plastic waste pose significant environmental challenges due to the low biodegradability, persistence, and widespread accumulation of polymeric materials in the environment. Polymers such as polypropylene (PP), polyethylene terephthalate (PET), and polyurethane (PU) are extensively used in industrial and domestic applications, contributing significantly to the generation of plastic waste. Although plastic recycling has increased considerably in India, a substantial amount of plastic waste remains to be managed through sustainable practices and value-added applications. The incorporation of waste polymers into construction materials offers a sustainable approach to reducing plastic waste while potentially enhancing the performance and strength characteristics of concrete. The present study evaluates the feasibility of using waste polyurethane as a partial substitute for cement in concrete production. This study is to assess the strength characteristics of concrete with polyurethane replacing cement at 25% and 50% levels and to compare its performance with that of conventional concrete. Concrete specimens were prepared using the specified proportions of polyurethane and evaluated through standard strength tests to determine their performance. The experimental results were compared with those of the control concrete to evaluate the effect of polyurethane incorporation on its strength characteristics. The findings may contribute to the development of sustainable concrete by promoting the effective reuse of polymeric waste in the construction industry. This approach can contribute to waste reduction, resource conservation, and the promotion of environmentally sustainable construction practices.

Keywords: Polymer; Plastic Waste; Polyurethane; Partial Cement Replacement; Properties; Mix Design; Specific Gravity; Fineness Modulus; Water Absorption; Compressive Strength.

1.0. Introduction

The swift expansion of population, urbanisation, industrialisation, and economic progress has led to a significant rise in the use of construction materials and manufactured goods (Babafemi et al., 2018 & R. Vinayagamoorthy, 2023). Plastics and other polymeric substances have gained significant prominence in contemporary civilisation due to their lightweight nature, resilience, adaptability, affordability, and resistance to moisture and environmental deterioration (Buekens, 2019; OECD, 2022b). Global plastic production has risen from over 234 million tonnes in 2000 to 460 million tonnes in 2019, whilst plastic trash output escalated from 156 million tonnes to 353 million tonnes in the same timeframe (OECD, 2022a). The growing buildup of plastic refuse has engendered significant ecological issues, as insufficient collection, recycling, and disposal may lead to the infiltration of plastics into land and water systems (Zhang & Su, 2020). As a result, there is a growing focus on recycling, repurposing, and integrating polymeric waste into building materials as methods to diminish waste production and foster a more circular economy (Ben Fraj et al., 2010).

Inadequate handling and disposal of plastic refuse have emerged as significant ecological issues globally. In contrast to numerous naturally occurring substances, traditional synthetic polymers typically have minimal biodegradability and can endure in the environment for prolonged durations (Law & Narayan, 2021). Improperly discarded plastic debris in public spaces, landfills, aquatic environments, and drainage systems can lead to environmental contamination and pose threats to human health and ecosystems. In metropolitan regions, the buildup of plastic waste may hinder drainage systems and lead to localised inundation, whilst plastic refuse infiltrating land and water ecosystems can negatively impact their structure and functionality (Tursi et al., 2022). Plastic pollution can adversely impact soil and water quality, with the disintegration of bigger plastic objects leading to the formation of microplastics that are progressively identified in terrestrial, freshwater, and marine ecosystems (Chen et al., 2024; Tian et al., 2023). Moreover, unregulated incineration of plastic refuse can emit toxic contaminants into the air, endangering both human and ecological well-being (Pathak et al., 2023; Verma et al., 2016). Consequently, efficient collection, source minimisation, recycling, repurposing, and enhanced utilisation of plastic waste are vital elements of sustainable waste management approaches and the shift toward a circular economy (Abbas & Alsaif, 2026; Law & Narayan, 2021).

Standard approaches to plastic waste management usually involve landfilling, burning, mechanical recycling, and reuse. Nevertheless, these strategies exhibit various technological and environmental shortcomings (Ismail & AL-Hashmi, 2008). The process of landfilling demands extensive land resources and is seen as a relatively low-value disposal option, while incineration has the potential to emit greenhouse gases and other hazardous pollutants if suitable emission-control measures are not adopted (Alrazen et al., 2025; Gu & Ozbakkaloglu, 2016). The efficacy of mechanical recycling is hindered by issues such as sorting difficulties, contamination, degradation, and the incompatibility among different polymer types, thereby affecting the quality and versatility of recovered materials (Gómez-Rojo et al., 2019). An effective method is the utilisation of waste polymers in construction materials, notably concrete and cement-based composites, where plastic waste can serve as a partial replacement for standard ingredients, thereby lessening the amount of waste for disposal and the demand for raw construction materials (Mounanga et al., 2008; Saikia & De Brito, 2012). Current assessments indicate that the addition of properly treated plastic waste to concrete can offer environmental and resource-saving benefits, yet its influence on workability, strength, durability, and various engineering attributes is significantly determined by the type, size, shape, and proportion of the incorporated plastic (Minde et al., 2024; Othman et al., 2023).

Polyurethane (PU) is a significant category of synthetic polymer synthesised via the interaction of hydroxyl group-containing substances, including polyols, with isocyanates. Through alterations in chemical composition, formulation, and production parameters, polyurethane can be synthesised in various forms such as flexible and rigid foams, elastomers, coatings, adhesives, sealants, and other specialised materials (Abdel-Rahman et al., 2019; Gómez-Rojo et al., 2019).

Polyurethane foam is extensively utilised in furniture, beds, automobile parts, thermal insulation, refrigeration devices, packaging, footwear, and various industrial goods. Rigid polyurethane foam is widely utilised as a thermal insulator due to its cellular composition, which offers low density and advantageous thermal insulation characteristics (Ben Fraj et al., 2010; Mounanga et al., 2008). The extensive fabrication and use of polyurethane items unavoidably produce waste throughout manufacturing operations, construction and remodelling endeavours, product replacements, and post-consumer disposal.

The rising utilisation of polyurethane necessitates the development of appropriate end-of-life management approaches. Polyurethane items pose challenges for traditional mechanical recycling methods due to their varied chemical compositions, often cross-linked or thermoset characteristics, and the multitude of forms in which they are produced (Kou et al., 2009; Rodrigo-Bravo et al., 2025). As a result, discarded polyurethane substances can be relegated to landfills or alternative waste-management methods, leading to the forfeiture of potentially significant polymer resources. These obstacles have prompted scholars to explore alternate approaches for the reclamation and enhanced utilisation of polyurethane waste. A viable strategy involves integrating waste polyurethane into construction materials such as lightweight concrete, cement mortar, and other cement-based composites (Ben Fraj et al., 2010; Gadea et al., 2010; Junco et al., 2018; Mounanga et al., 2008). Such methods may diminish the volume of polyurethane waste necessitating treatment while concurrently lowering the use of traditional construction materials.

The construction sector presents a significant opportunity for the application of waste materials due to the vast amounts of resources used in the creation of structures and infrastructure. The integration of appropriate waste polymers into concrete may effectively tackle two ecological issues at once: diminishing the volume of polymer waste needing disposal and lessening the reliance on traditional construction materials (Babafemi et al., 2018; Gu & Ozbakkaloglu, 2016; Mohi-Ud-Din et al., 2025). The engineering efficacy of concrete incorporating waste polymers is influenced by variables including the type of polymer, particle dimensions, surface properties, replacement ratio, mixing methodology, and the interaction between the polymer and the cementitious matrix (Arroyo et al., 2024; Minde et al., 2024; Saikia & De Brito, 2012). Consequently, empirical assessment is essential to ascertain suitable substitution ratios and to evaluate the influence of waste polyurethane on concrete characteristics like workability, density, compressive strength, tensile strength, and durability.

The strength properties of concrete are crucial as it is extensively utilised in construction projects that require it to endure imposed loads safely. Compressive strength is one of the most often evaluated mechanical qualities for determining the performance and quality of concrete, due to the significant compressive pressures encountered by several concrete components (Abdel-Rahman et al., 2019). Additional characteristics, such as tensile strength, flexural strength, density, workability, and durability, are also significant according on the specific application and service conditions (Abbas & Alsaif, 2026; Mohi-Ud-Din et al., 2025; Siddique & Akhas, 2024). Assessing compressive strength is thus very pertinent when examining the viability of waste polyurethane as a partial substitute for cement.

1.1. Study Objectives

The primary objective of this research is to assess the viability of employing waste polyurethane as a partial substitute for cement in concrete. and to analyse its impact on the strength properties of the resultant concrete.

1. To prepare conventional concrete without polyurethane as the control mix.
2. To prepare concrete mixes with 25% polyurethane replacement of cement.
3. To prepare concrete mixes with 50% polyurethane replacement of cement.
4. To determine the workability of fresh concrete.
5. To determine the compressive strength of concrete specimens.

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2.0. Material and Methodology

The current experimental study was conducted to assess the viability of employing waste polyurethane as a partial substitute for cement in concrete. The research examines the impact of integrating polyurethane on the strength properties of concrete. Standard concrete was formulated as the reference mixture, whilst waste polyurethane was utilised to substitute a fraction of cement at replacement rates of 25% and 50%.

The experimental program involved the collecting and characterisation of materials, the manufacture of waste polyurethane, the formulation of concrete mixtures, the casting of specimens, the curing process, and the assessment of strength parameters by standard laboratory testing methods. The outcomes derived from polyurethane-modified concrete were juxtaposed with those of traditional concrete to assess the impact of elevated polyurethane levels. The comprehensive experimental approach utilised in the research.

The primary constituents employed in the formulation of concrete specimens included cement, fine aggregate, coarse aggregate, water, and waste polyurethane. The materials were chosen and arranged in accordance with the specifications of the experimental protocol. Meticulous attention was given throughout the processes of weighing, mixing, casting, and curing to ensure uniformity across all concrete mixtures.

The substances employed in the experimental study were cement, fine aggregate, coarse aggregate, water, and waste polyurethane. The chosen grade of Standard Portland cement served as the principal cementitious substance and was kept in a dry setting to avert moisture uptake and early hydration. Natural fine aggregate underwent cleaning, sieving, and appropriate grading before to application, while its specific gravity, water absorption, and fineness properties were evaluated to guarantee uniformity in the concrete compositions. Crushed natural coarse aggregate of appropriate dimensions was utilised and purified to exclude dust, clay, organic substances, and other contaminants. Drinkable water was utilised for both the mixing and curing of concrete, with its volume regulated based on the chosen mix ratios. Recycled polyurethane was utilised as the substitute material and sourced from a suitable waste origin. The gathered polyurethane underwent meticulous examination and cleansing to eliminate dust, grime, and other substances. Subsequently, it was desiccated under appropriate conditions and reduced into smaller fragments through cutting, shredding, or crushing based on its physical characteristics. When required, the treated polyurethane was sifted to achieve a comparatively consistent particle dimension. Ultimately, the formulated polyurethane was meticulously measured in accordance with the designated replacement ratios and preserved in a pristine, arid setting until its integration into the concrete compositions.

2.1. Mix Proportioning

The control mixture consisted of conventional concrete elements lacking polyurethane. In PU25, one-fourth of the specified cement quantity was replaced with reclaimed polyurethane. In PU50, fifty percent of the specified cement quantity was replaced with waste polyurethane. The remaining elements of the concrete were maintained in alignment with the selected mix design. This arrangement enabled the evaluation of the effects of enhanced polyurethane replacement on the longevity of concrete. Grade of concrete, size of cube casting, different proportion of the materials like glass and fly ash etc. which replaces the cement etc. are interpreted as:

- Grade of concrete - M25.
- Nominal concrete - 3 cubes of 1:1:2 ratio.
- Cement replaced by waste plastic material (foam materials).
- 3 cubes with 25% replace of cement.
- 3 cubes with 50% replace of cement.

2.2. Setting Time of Cement

The properties of the cement's setting were assessed utilising the Vicat equipment. A 500 g sample of cement was mixed with water at 0.85 times the amount necessary for achieving standard consistency. The cement mixture was formulated and positioned in the Vicat mould within the designated timeframe. The timer was initiated instantly upon the addition of water to the cement.

2.2.1. Initial Setting Time

The preliminary setting time was established by delicately descending the Vicat needle until it touched the cement paste surface and thereafter permitting it to infiltrate the specimen. At first, the needle significantly pierced the paste. As the cement paste progressively diminished in flexibility, the depth of penetration reduced. The first setting time was defined as the duration from when water was added to the cement until the needle penetrated roughly 33–35 mm from the upper surface of the test specimen.

2.2.2. Final Setting Time

The ultimate setting duration was ascertained by substituting the conventional Vicat needle with a circular accessory. The cement paste was deemed to have attained its ultimate setting state when the center needle left an imprint on the surface, while the circular cutting edge did not. At this juncture, the cement paste had attained adequate rigidity, allowing the central needle to penetrate the specimen by no more than around 0.5 mm.

2.3. Specific gravity of cement

The specific gravity of the Ordinary Portland Cement (OPC) examined in the study was ascertained utilising a 250 mL Le-Chatelier flask and kerosene as the displacement medium. A balance with a precision of 0.1 g was employed to ascertain the mass of the cement. The Le-Chatelier flask was initially dried comprehensively to remove any remaining moisture. Kerosene was subsequently added to the flask until it reached the first reference mark. Around 60 grams of cement were meticulously introduced into the flask. The cement and kerosene were sufficiently blended to eliminate trapped air bubbles, and the flask was permitted to rest for around 30 minutes prior to documenting the final liquid level.

2.4. Specific Gravity of Fine Aggregate

The specific gravity of fine aggregate is defined as the ratio of the mass of a certain volume of aggregate to the mass of an equivalent volume of water at a designated temperature. The Specific gravity of fine aggregate is calculated as shown in Table 1.

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2.5. Specific Gravity of Coarse Aggregate

The specific gravity of coarse aggregate is defined as the proportion of the mass of a particular volume of aggregate to the mass of an equivalent volume of water at a designated temperature. It signifies the concentration of the aggregate particles. The Specific gravity of fine aggregate is calculated as shown in Table 1.

2.6. Water Absorption of Fine Aggregate

The water absorption of fine aggregate refers to the quantity of water taken in by the pores of the aggregate, represented as a percentage of the aggregate's oven-dry weight. Coarse aggregate exhibiting elevated water absorption often possesses a greater number of pores and may necessitate additional water during the concrete mixing process. Consequently, water absorption must be taken into account when calculating the effective water–cement ratio and mix proportions. The water absorption of fine aggregate is computed as given in Table 1.

2.7. Water Absorption of Coarse Aggregate

The water absorption of coarse aggregate refers to the volume of water taken in by the pores of aggregate particles, represented as a percentage of the aggregate's oven-dry weight. Coarse aggregate exhibiting elevated water absorption typically possesses more porosity and may take in additional mixing water. Consequently, the absorption of water must be taken into account when calculating the water–cement ratio and the proportions of the concrete mix. The water absorption of coarse aggregate is computed as given in Table 1.

2.8. Fineness Modulus of Fine Aggregate

A reduced fineness modulus signifies finer sand, which typically necessitates additional water and may expand the surface area to be covered by cement paste. A greater fineness modulus signifies sand with a coarser texture. Fineness modulus of fine aggregate is computed in Table 1.

2.9. Sieve Analysis of Coarse Aggregate

Sieve analysis of coarse aggregate involves assessing the particle-size distribution (gradation) of coarse aggregate by passing it through a sequence of standardised sieves. Adequately graded coarse aggregate enhances packing efficiency, minimises voids, optimises workability, and decreases the necessity for cement paste. Sieve analysis of coarse aggregate is computed in Table 1.

Table 1. Values of Test on Properties of Cement Concrete.

Sl. No.	Test on Properties	Value
1.	Specific gravity of cement	3.157
2.	Specific gravity of fine aggregate	2.45
3.	Specific gravity of coarse aggregate	2.77
4.	Water absorption of fine aggregate	0.143
5.	Water absorption of coarse aggregate	0.211
6.	Fine modulus of fine aggregate	3.021
7.	Fine modulus of coarse aggregate	7.32

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2.10. Mixing of Concrete with Control

The concrete employed in this research was M25 grade with a water-cement ratio of 0.45. Ordinary Portland Cement (OPC) of 43 grade, with a unit density of roughly 1440 kg/m³, was utilised as the binding agent. Coarse aggregates with nominal diameters of 12 mm and 20 mm, and a density of around 1600 kg/m³, were utilised as the coarse aggregate. Natural dry sand, with a density of roughly 1600 kg/m³, served as the fine aggregate. Furthermore, waste foam plastic was integrated into the concrete as a substitute material to examine its influence on the characteristics of M25 concrete. The reference concrete was formulated without the inclusion of plastic trash, whereas the altered concrete mixtures incorporated the prescribed amount of waste foam plastic. The formulated mixtures were assessed by fresh and hardened concrete examinations to determine their workability and strength properties.

2.11. Slump Cone Test

The slump cone test is an uncomplicated and cost-effective method employed to assess the workability or consistency of newly mixed concrete. It is frequently conducted at construction sites and laboratories to assess the consistency of concrete between batches. The characteristics of cement and aggregates, water volume, additives, air volume, temperature, mixing and transport techniques, sampling methodologies, and the duration post-mixing all affect the slump of concrete. Sanitise and lubricate the slump cone and position it on a flat, impermeable surface. Pour the cone with fresh concrete in four uniform layers, compacting each layer 25 times with a tamping rod as shown in Figure 1. Even out the upper surface and tidy the adjacent space. Gradually elevate the cone in an upright position without disrupting the concrete. Assess the slump by calculating the disparity between the initial elevation of the cone and the height of the settled concrete. The outcome demonstrates the uniformity and functionality of the concrete. The vertical settlement seen shall be documented in millimetres of subsidence of the specimen throughout the examination. The blend was verified to possess a medium workability, exhibiting a slump value ranging from 60 to 100 mm, specifically 70 mm or 7 cm. The Slump Value is depicted in Figure 2.

Figure 1. Slump Cone Test.

Figure 2. Failure of Slump Cone.

2.12. Preparation of Cubes

The equipment utilised for the casting and evaluation of concrete cubes comprised 150 mm × 150 mm × 150 mm cube moulds, a 16 mm diameter bull-nosed tamping rod, a steel float/trowel, a compressive strength testing apparatus, a curing tank, a weighing scale, a pan and hammer, a cylindrical mould, and sieve analysis tools. The concrete cubes were fabricated via a sequence of procedures, encompassing the cleansing and repair of the mould, amalgamating cement with recycled foam plastic, positioning and compacting the concrete, refining the surface, and curing the samples. The cube mould was meticulously sanitised, and a fine coat of mold-release oil was evenly distributed across its inside surfaces. Surplus oil was eliminated to guarantee that no discernible oil persisted on the surface. The mould was thereafter affixed to the base plate, guaranteeing that all seams were thoroughly sealed to avert any leaking of cement slurry throughout the casting process. The necessary amounts of cement and discarded foam plastic were meticulously measured and positioned in a pristine mixing container. The components were meticulously blended by hand with a trowel until an even dispersion of the foam plastic in the cement was attained. The leftover concrete components were subsequently incorporated in accordance with the designated mixing ratios, followed by the necessary volume of water. The complete blend was meticulously combined until a uniform concrete mixture was achieved as shown in Figure 3.

Figure 3. Mixing of Concrete and Waste Foam Plastic.

Fresh concrete was gathered from representative segments of the prepared mixture and deposited into the 150 mm cube moulds in three about equal strata. Each stratum was densified utilising a 16 mm diameter tamping rod through the application of 35 strokes evenly across the cross-section. Upon completing the filling and compaction of the last layer, surplus concrete was eliminated, and the upper surface was refined using a steel trowel to provide a sleek and even finish. The moulds were left undisturbed post-casting to enable the concrete to cure. The specimen identifier and casting date were subsequently inscribed on the specimens for future curing and evaluation as shown in Figure 4.

Figure 4. Preparation of Cubes.

2.13. Curing of Concrete Specimens

Curing is a crucial phase in concrete manufacturing as it supplies the necessary moisture and temperature for ongoing cement hydration and strength enhancement. Proper curing facilitates the concrete's attainment of desired mechanical characteristics and mitigates the risk of premature moisture evaporation, which can negatively impact strength and longevity. In the current study, curing was conducted under regulated laboratory settings for both the standard concrete and the concrete blends incorporating waste foam plastic.

Following the casting process, the concrete samples were first retained in their moulds to facilitate the development of adequate early-age strength. Roughly 8–10 hours post-casting, the cube moulds were enveloped in damp hessian fabric to reduce moisture evaporation from the concrete. The upper sections of the moulds were then enveloped with polythene sheets to enhance moisture retention and to avert direct water exposure to the newly poured concrete surface.

The samples were extracted from the moulds after around 24±0.524 ± 0.5 hours of casting. The mould bolts were meticulously undone, and the concrete cubes were extracted without harming the rather fragile early-age specimens. Upon demoulding, the specimens were promptly relocated to a curing tank filled with pristine water as shown in Figure 5. The concrete cubes were entirely immersed during the curing phase to ensure a constant supply of moisture for cement hydration.

Figure 5. Curing of Concrete.

2.14. Compressive Strength Test

The compressive strength assessment was performed to ascertain the load-bearing capability of the concrete samples when subjected to compression. Cubes of 150 mm × 150 mm × 150 mm were extracted from curing at the designated testing age, and surface moisture was eliminated prior to testing. The sample was positioned centrally between the platens of the compression testing apparatus. The load was incrementally introduced until failure ensued. The highest load borne by the specimen was documented. At the end of each curing period, the concrete cubes were removed from the curing tank and tested using a compression testing machine (CTM). The cube was positioned centrally between the loading platens of the machine, and the load was applied continuously until failure. The maximum load sustained by each specimen was recorded and used to determine the compressive strength.

3.0. Results and Discussion

The findings from the study on utilising waste polyurethane as a partial substitute for cement in concrete. The research evaluated standard concrete as the baseline mix with concrete including waste polyurethane at substitution rates of 25% and 50%.

3.1. Compressive Strength Test

The compressive strength of the concrete formulations was assessed utilising standard cube specimens with dimensions of 150 mm × 150 mm × 150 mm. The samples were created for the reference concrete and for concrete blends where cement was partially substituted with discarded foam plastic. Subsequent to casting, the samples underwent the prescribed curing protocol and were evaluated at the given curing intervals.

The calculation of compressive strength was performed utilising: Upon the conclusion of each curing duration, the concrete cubes were extracted from the curing tank and evaluated with a compression testing machine (CTM). The cube was situated centrally between the machine's loading platens, and the load was exerted persistently until failure occurred. The peak load endured by each specimen was documented and utilised to ascertain the compressive strength as given in equation (1)

$$fc = P/A \quad (1)$$

where fc is the compressive strength of concrete (N/mm^2), P is the maximum applied load at failure (N), and A is the loaded cross-sectional area of the cube (mm^2).

Table 2. Test Results for Nominal Mix Concrete.

Compressive strength of 1st cube @ 7 days	: 25.82N/mm^2
Compressive strength of 2nd cube @ 14 days	: 26.36N/mm^2
Compressive strength of 3rd cube @ 28 days	: 29.28N/mm^2

Table 3. Test Results When Cement Is 25% Replaced by Waste Plastic Material (Foam Plastic).

Compressive strength of 1st cube @ 7 days	: 9.77N/mm^2
Converting in to 28 days	: 9.77/0.9 = 10.85N/mm^2
Compressive strength of 2nd cube @ 14 days	: 15.24N/mm^2
Converting in to 28 days	: 15.24/0.9 = 16.93N/mm^2
Compressive strength of 3rd cube @ 28 days	: 17.86N/mm^2
Converting in to 28 days	: 17.86 /0.9 = 19.84N/mm^2

Table 4. Test Results When Cement is 50% Replaced by Waste Plastic Material (Foam Plastic).

Compressive strength of 1st cube @ 7 days	: 5.2N/mm^2
Converting in to 28 days	: 5.2/0.9 = 5.77N/mm^2
Compressive strength of 2nd cube @ 14 days	: 6.97N/mm^2

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Converting in to 28 days	: $6.97/0.9 = 7.75 N/mm^2$
Compressive strength of 3rd cube @ 28 days	: $7.82 N/mm^2$
Converting in to 28 days	: $7.82/0.9 = 8.68 N/mm^2$

3.2. After testing of concrete cubes

The concrete cube samples underwent axial compression testing utilising a compression testing apparatus. The load was incrementally and consistently applied until failure ensued. The peak load endured by each specimen at the point of collapse was documented as the failure load and utilised to ascertain the associated compressive strength of concrete as shown in Figure 6.

Figure 6. Cube Failure on Load.

Table 5. When Cement Is 25 % Replaced by Plastic Waste (Foam Plastic).

Grade of Concrete	Test Results (N/mm^2)	Average Strength Obtained (N/mm^2)	Average Strength Required (N/mm^2)	ITR value	Result
M25	10.85	15.87	27.1	>22 Not okay	Fail
	16.93				
	19.84				

Table 6. When Cement is 50% Replaced by Plastic Waste (Foam Plastic).

Grade of Concrete	Test Results (N/mm^2)	Average Strength Obtained (N/mm^2)	Average Strength Required (N/mm^2)	ITR value	Result
M25	5.77	7.4	27.1	>22 Not okay	Fail
	7.75				
	8.68				

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The Compressive strength of concrete when cement replaced by plastic waste (foam plastic) indifferent proportion as shown in Table 5 and 6 and also comparison of compressive strength of concrete when cement is replaced by plastic waste (foam plastic) in different proportions by line graph and bar chart are presented in Figure 7 and 8.

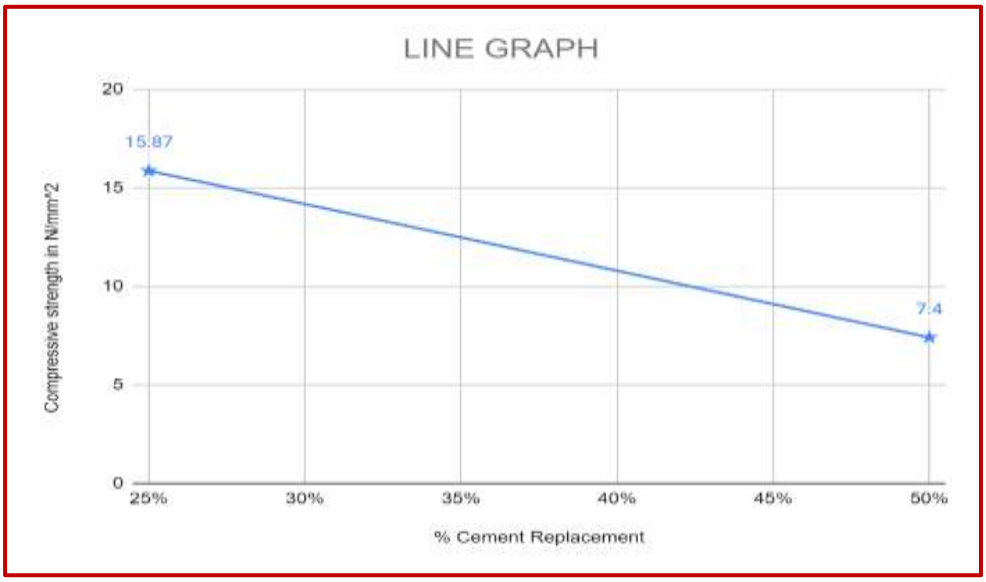

Figure 7. Comparison of Compressive Strength of Concrete When Cement is Replaced by Plastic Waste (Foam Plastic) in Different Proportions by Line Graph.

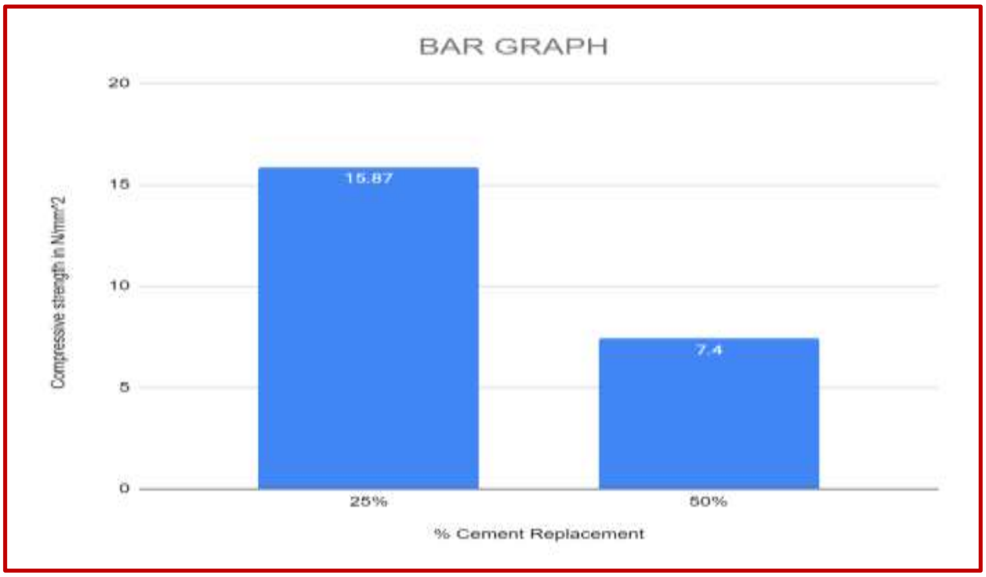

Figure 8. Comparison of Compressive Strength of Concrete When Cement is Replaced by Plastic Waste (Foam Plastic) in Different Proportions by Bar Chart.

4.0. Conclusion

The current experimental study assessed the impact of substituting a portion of cement with waste foam plastic in M25 concrete. From the experimental findings, the results demonstrate that substituting 25% and 50% of cement with waste foam plastic is inadequate for attaining the necessary strength characteristics of M25 structural concrete under the examined conditions. Additional refinement is required before waste foam plastic may be deemed a feasible component for structural concrete uses.

5.0. Future Recommendations

1. Subsequent research can explore the substitution rates of waste polyurethane at 5%, 10%, 15%, 20%, 30%, and 40%.
2. These substitution values can assist in determining the ideal proportion of polyurethane for cement replacement.
3. The influence of polyurethane on the split tensile strength of concrete can be assessed.
4. The bending strength of polyurethane-enhanced concrete warrants examination.
5. Subsequent investigations may evaluate the load-bearing capacity and fracture characteristics of the altered concrete.
6. Scanning Electron Microscopy (SEM) is applicable for analysing the microstructure of concrete.
7. XRD analysis can be employed to identify the crystalline phases inside the concrete matrix.

Declarations

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The authors did not receive any funding from public or private organization(s) for the submitted work.

Conflict of interest

The authors declare that there was no conflict of interest.

Consent for publication

The authors declare that this manuscript does not contain any personal data or sensitive information that requires consent for publication.

Author contributions

Ambiga Kannapiran carried out writing, conceptualization, methodology, data analysis. R. Vinayagamoorthy and Milon Selvam Dennison did writing and reviewing, and V. Sanjaykrishna - original draft preparation and editing.

Availability of data and material

All data generated or analyzed during this study are included in this article.

Ethics and Consent to Participate

Not applicable.

Clinical Trial Declaration

Not applicable

Declaration of Artificial Intelligence

The authors declare that no artificial intelligence tools were used in the writing, data analysis, or interpretation of findings in this manuscript. All content was produced solely by the authors.

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