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# Experimental Investigation On Light Weight Concrete By Uisng Paper Plastic Aggregates

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**Abstract**

Lightweight concrete (LWC) uses lightweight aggregates (e.g., expanded clay, perlite) and has benefits like low density and thermal insulation. This study focuses on using paper-plastic aggregates (PPA) to enhance LWC. Various PPA replacement ratios (0%, 50%, 75%, 100%) were tested for properties such as workability, compressive strength, and density. Results show that while PPA-based LWC reduced workability at higher content, it lowered density by 30%, providing a sustainable, eco-friendly construction solution.

***Keywords***: Lightweight concrete, paper-plastic aggregate (PPA), sustainable construction, waste management, lightweight paper plastic aggregate concrete (LWPPA).

## 1. INTRODUCTION

Concrete is a widely used material due to its affordability, durability, and versatility, with India consuming 7.3 million cubic meters annually. The cement industry, however, contributes 7% of global CO2 emissions, fuelling the need for sustainable alternatives. This study explores using paper and plastic waste as aggregates in lightweight concrete, aiming to reduce environmental impact and improve properties. Global waste management challenges and resource scarcity highlight the urgency of finding new materials. By incorporating waste into concrete, we can address environmental concerns, reduce resource use, and potentially enhance concrete performance, offering a sustainable solution for the construction industry.

### Light Weight Concrete

Lightweight concrete is created using low-density aggregates like pellite, volcanic pumice, and scoria, resulting in a density range of 1440 to 1840 kg/m³, making it lighter than regular concrete. This type of concrete, which can reach compressive strengths of 7,000 to 10,000 psi, is ideal for modern constructions requiring smaller foundational cross-sections. Notably, the incorporation of paper and plastic waste as artificial aggregates has emerged as an innovative approach to producing lightweight concrete, further enhancing its mechanical properties. The properties of lightweight aggregate concrete vary based on the aggregate's texture and shape, which directly influence the workability and overall composition of the concrete. Its compressive strength typically ranges between 3,000 and 5,000 psi, meeting industry standards, while its density and absorption rates are influenced by the aggregate's moisture content and particle density. The internal curing ability of lightweight concrete, due to the slow-release moisture from the lightweight aggregate's pores, improves cement hydration, contributing to its durability. Additionally, its lower thermal conductivity and enhanced fire resistance make it a preferred choice in various applications.

Lightweight aggregate concrete is characterized by consistent properties, low specific weight, and a porous structure that contributes to effective bonding with cement. It is widely used in applications like general-purpose screeds, insulation of water pipes, and structural purposes, particularly where reduced dead load is essential. The use of lightweight concrete in structures like the Bank of America Building in Charlotte, North Carolina, demonstrates its effectiveness in reducing dead load and enhancing structural performance. Additionally, it is utilized in high-rise buildings, decks, and bridges, offering thermal insulation and fire resistance, making it a versatile material in construction.

While lightweight concrete offers significant advantages such as reduced dead load, improved insulation, ease of handling, and better fire resistance, it also has some limitations. These include lower compressive strength compared to conventional concrete, durability concerns, sensitivity to moisture, and higher costs due to the production process. Additionally, the availability of lightweight aggregates may be limited, and its suitability for high-load-bearing applications can be a concern. Paper plastic aggregates, created from a composite of paper and plastic waste, present a sustainable alternative to traditional concrete aggregates. These materials are lightweight, improve the workability of concrete mixtures, and enhance the durability of the final product by reducing shrinkage and cracking. The use of these aggregates can significantly reduce the weight of concrete structures, contributing to cost savings in transportation and handling while promoting environmental sustainability.

In a research project involving paper plastic aggregates, material characterization is crucial to understanding their properties and compatibility with cementitious materials. The mix design must be carefully developed to optimize performance parameters, and rigorous testing and quality control measures should be implemented throughout the construction process. The project also requires a thorough evaluation of the structural performance and long-term durability of the concrete under various environmental conditions. Feasibility studies and regulatory compliance are essential to ensure that paper plastic aggregate concrete meets industry standards and is viable for widespread use in construction. The documentation and reporting of this research will provide valuable insights and recommendations for adopting sustainable practices in the construction industry, promoting the use of recycled materials like paper plastic aggregates in concrete manufacturing.

### 1.2 Problem Identification

Conventional concrete, known for its heavy weight, poor thermal insulation, susceptibility to cracking, and significant environmental impact, poses challenges in handling, energy efficiency, and durability. Its production, particularly cement, contributes to high greenhouse gas emissions and costs, especially in large-scale projects. These drawbacks have driven the development of lightweight concrete, which offers better performance and sustainability, addressing the issues of weight, insulation, environmental impact, and cost.

### 1.3 Objectives

This study aims to explore the feasibility of incorporating plastic waste into concrete as a substitute for fine aggregate, promoting recycling as a viable disposal method. It assesses the mechanical properties, compressive and flexural strengths, and long-term resilience of lightweight concrete with paper plastic aggregates (PPA). The research evaluates PPA's suitability in M-25 mix designs, their environmental impact, and sustainability, including effects on air and water quality. By comparing PPA with alternative lightweight aggregates, the study seeks to identify the most cost-effective options. The project also aims to optimize construction practices and establish best practices for the widespread use of PPA in the construction industry, using field testing, lab testing, and modeling to enhance understanding and application.

## 2. LITERATURE REVIEW

**Gopika, Viswanath, and S. P. Akshara (2019):** The use of almost weightless polystyrene in place of gravel is one example of lightweight material development that has been the focus of research. A few investigations have been led involving polystyrene as a lightweight total. To protect buildings from seismic damage, Suprapto Siswosukarto et al. advocated using lightweight construction materials. They additionally encouraged utilizing precomputation to make polystyrene substantial boards.

**T. Parhizkar et.al:** Displayed probes the qualities of volcanic pumice lightweight totals in cements. At the conclusion, the lightweight coarse and fine aggregates concrete, which consists primarily of natural fine aggregates. The review uncovers those various results, like elasticity and drying shrinkage, exhibit that these lightweight cements match the particulars.

**Chandni and Anand (2016):** investigated the use of recycled waste as a filler in foam concrete. The exploratory outcomes show that using reused trash bin major areas of strength for make concrete appropriate for load bearing wall applications. In addition, they came to the conclusion that using a PCE-based superplasticizer to strengthen foam concrete was effective. They likewise resolved that low unambiguous Gravity fillers require a higher water-to-solids proportion to deliver usable froth substantial blends.

**Vakhshouri, Behnam, et al. (2019):** A Concentrate on Lightweight Concrete. It lessens the dead heap of structures. This is pivotal for diminishing venture costs. The primary application for EPS dabs is in designing. at least since the 1950s. Polystyrene total can make lightweight cement with unit loads going from 1200 to 2000 kg/m3. The highlights areas of strength for are protection and low intensity conductivity. Total is utilized in both mortar and cement. EPS globules can be utilized as a standard cement framing material. examined the light-weight concrete Extended polystyrene is a lightweight material. Extended polystyrene squander is utilized as a lightweight total in non-primary cement, with unit loads going from 950 kg/m3 to 1350 kg/m3. It is Since the 1950s.The elements of polystyrene total cement incorporate compressive strength and variable thickness.

**Bamdad Ayati et al. (2018):** The clay that was used to make lightweight aggregates was looked at. The appropriate clay lightweight aggregate for concrete is strong, spherical, 4-14 mm in diameter, and porous. Earth's permeability is the essential determinant of substantial thickness, water assimilation, and strength. The high the temperature used to make light extended earth total created ceaseless pores, which Expanded the total's porosity. The temperature rose above the pyro plasticity range, which resulted in a decrease in the porosity and size of the pores. The sluggish cooling of LECA during assembling upgraded total squashing strength.

**In 2018, Elango A and Ashok Kumar A conducted a study on concrete using plastic fine aggregate:** Crushed aggregates, river sand, and grade OPC 53 were used. Fine aggregates were replaced by plastic in proportions of 10%, 20%, and 30%. They test the concrete samples' mechanical and durability properties. The strength of the concrete had diminished, they discovered. Nonetheless, the substantial exhibited great protection from corrosive attacks and expanded adaptability. As a result, they found that flexible aggregate concrete can be used in applications requiring high durability but low compressive strength.

**M Mahesh, B Venkat Narsimha Rao, and CH Satya Sri in 2016**: chipped away at reusing polyethylene plastic waste in concrete. They added 2%, 4%, and 6% pulverized/non-pulverized polyethylene to the concrete after designing the mix. They reasoned that squander plastic can be successfully reused while holding mechanical characteristics (5-10%). At the point when the level of plastic was expanded, the early strength diminished decisively, however by 28 days, the strength had arrived at the degree of standard M25 concrete. For decreased rate expansion (2-4%) of plastic, there was no huge variety in 7-, 14-and 28-days pressure strength and split elasticity.

**Praveen Mathew et al. [2013]:** The compressive, modulus of elasticity, split tensile, and flexural strengths of concrete were examined when recycled plastic was used as a partial substitute for coarse aggregate. After cooling, heat the pieces of plastic to the desired temperature and crush them to produce coarse aggregate. The investigation discovered that plastic total has lower pulverizing (2.0 versus 28 for normal total), explicit gravity (0.9 versus 2.74 for natural aggregate) and density (0.81 in comparison to 3.14 for regular total) than normal coarse total. The results of the test showed that natural coarse aggregate could be replaced with 20 percent plastic aggregate. At the point when the example droop test was performed, there was an expansion in functionality demonstrated. In contrast with grade replacement, volumetric replacement of normal total with plastic total was more successful. At When compared to conventional concrete, plastic coarse aggregate had a significantly lower strength at 400°C. The compressive strength expanded by 28%, while the split rigidity and modulus of flexibility diminished. Matrix and plastic aggregate bond better when an appropriate admixture of 0.4% cement by weight is added. Notwithstanding, further examination is expected to address the pliable way of behaving of cement with 20% plastic total.

**M.A. Kamaruddin et al. (2000):** "Likely utilization of Plastic Waste as Development Materials: Late Advancement and Future Possibility" Plastic-based items are broadly utilized for customer bundling around the world. Notwithstanding, high plastic utilization has brought about a huge expansion in trash. Alternative uses for plastic waste include the production of concrete and other products with added value. This study sums up ongoing improvements in fostering a substantial combination with plastic waste as fractional total substitution during produce. We drew conclusions based on laboratory results from all pertinent D research articles after analyzing data from previous studies on plastic trash in concrete mixtures.

**Ahmed Trimbakwala (2003):** “As of March 31, 2015, India has the world's second largest road network, with approximately 5,472,144 kilometers (3,400,233 miles)." "Plastic Roads Use of Waste Plastic in Road Construction" Plastic trash bin be used as an added substance in street building, broadening its life and tending to ecological worries. Field tests have demonstrated its adequacy. Plastics have for quite some time been utilized in street development. PVC or HDPE pipe mat intersections are now being used. Plastic mats are made by connecting HDPE or PVC pipes together. Squander plastic is crushed into powder, and 3 to 4% is consolidated in.

**Shi, Wenbo, et al (2016):** The researcher discovered that EPS volume ratios of 0%, 20%, 30%, and 40% were achieved when matrix or coarse aggregate were replaced. demonstrates that the two approaches to design have roughly the same compressive strength. He used cyclic loads of 40 KN, 50 KN, and 60 KN at a frequency of 5 Hz, 50 000 or 100 000 times. The application of EPS beads concrete in long-term recyclic dynamic load engineering was impacted by this study's findings. Besides, he asserts that L.W.C. (Light Weight Concrete) has no environmental impact due to the absence of poisons or harmful substances in the produced EPS particle and its low energy consumption.

**Soni Kumari et al (2020):** Natural aggregate concrete (LWAC) is partially replaced by pumice aggregate (PA), a locally accessible lightweight aggregate. By volume, this new LWAC substitutes 10%, 20%, 30%, 40%, and 50% PA for coarse aggregate. The reason for this study was to look at the mechanical and sturdiness characteristics of LWAC to recognize the ideal Dad substitution level. Dad's characteristics were assessed through tests on functionality, compressive strength, thickness, all out water ingestion, and ultrasonic in addition to speed (UPV). It is inferred that the LWAC has appropriate strength and thickness.

**Murat Emre Dilli et al. (2015):** Standard concrete's strength and elastic properties were compared to those of lightweight concrete with expanded clay aggregates. Three substantial combinations were made utilizing ordinary coarse total and two sorts of extended mud totals. after mining for 28 days and 120 days. Substantial thickness expanded as compressive strength expanded. Clay particles expand even in concrete with a low water-to-cement ratio. with a lot of water absorption, which led to better internal curing. The modulus of versatility of cement expanded simultaneously with its solidarity.

**Kan, Abdulkadir, and Ramzan Demirboğa:** Concrete panels' fire resistance, compressive strength, and thermal conductivity were all examined in the study. It was determined that increasing the volume of EPS in concrete decreases its compressive strength and thermal conductivity. To research the underlying way of behaving of froth substantial boards in pressure and flexure, precisely reused EPS dabs were utilized as totals. To increase stiffness, the research suggests using boards made of cement fiber.

**Mugahed Amran et al. (2015):** In their review, they investigated frothed substantial fixings, creation strategies, and attributes affecting the utilization of cell concrete, for example, crude fixings, creation processes, and expected thickness-based characteristics.

**Qusim S Khan et al. (2018)**: conducted research on foam concrete's use of recycled glass powder. In their 2013 review, M. Glass that had been thrown away was looked into as a possible substitute for fine aggregate in concrete by Iqbal Malik et al. Rahman et al. (2018) explored the presentation of lightweight cement with rice husk debris and glass powder. Elango et al. (2018) explored ordinary cement by involving plastic junk as a fine total. Raj (2019) looked into foam concrete's physical and functional properties.

### 2.1 Methodology

The experimental investigation into lightweight concrete using paper plastic aggregate begins with a comprehensive literature review to understand existing knowledge and research gaps. Following this, the study focuses on identifying and preparing the materials used, including cement, coarse aggregate, and fine aggregate. The core of the investigation involves developing a mix design and conducting tests on the fresh concrete to ensure proper consistency and workability. Once the mix is finalized, casting and curing of the concrete specimens are performed. After the curing period, various tests are conducted on the lightweight concrete to evaluate its properties and performance. The findings from these tests lead to a conclusion that summarizes the effectiveness of using paper plastic aggregate in producing lightweight concrete and its potential implications for construction practices.

## 3. MATERIAL AND METHODS

### 3.1 Cement

Cement is a critical construction material, typically in powdered form, that hardens when mixed with water. This study uses Portland pozzolana cement (fly ash-based), which has a specific gravity of 3.15. Cement is used in mortar and concrete for various construction applications, from grouting to making blocks and tiles. It is a widely used building material due to its versatility.

### 3.2 Fine Aggregate

Fine aggregate, passing through a 4.75 mm sieve, is used as a filler in concrete. River sand is used in this study, with specific gravity ranging from 2.4 to 2.6.

### 3.3 Coarse Aggregate

Coarse aggregate, larger than 4.75 mm, provides strength and stability to concrete. It is typically obtained from quarries.

### 3.4 Lightweight Concrete

Lightweight concrete is produced by creating air-filled voids or using aggregates with high void content. It offers benefits like improved thermal insulation and reduced density.

### 3.5 Lightweight Aggregate Concrete

Developed in the 1950s, this concrete uses aggregates like expanded clay, slate, or industrial byproducts to achieve low density and high thermal insulation.

### 3.6 Paper Plastic Aggregates

Combining paper and plastic waste to form aggregates, this approach offers environmental benefits and can improve thermal insulation and reduce concrete density. Proper composition and adherence to building codes are essential.

### 3.7 Water

Potable water, free from impurities, is used in concrete mixing, ensuring proper hydration and quality of the concrete.

### 3.8 Plastic and Paper Waste Collection

Identify and collect plastic and paper waste from various sources, then process and grind these materials for use in concrete.

### 3.9 Making Paper Plastic Aggregate

Shred and mix paper and plastic waste, then cure and dry the mixture to create aggregates for construction use.

### 3.10 Mix Design: IS 10262 (2019)

The concrete mix for this project is of Grade M25, using Portland Pozzolana Cement. The maximum nominal size of the aggregate is determined based on the mix design specifications. The water-cement ratio is set at 0.50 but has been adjusted to 0.45 based on previous experience for improved strength and durability. The mix is designed to achieve a workability with a slump of 100 mm to ensure ease of placement and proper compaction. Given the severe exposure conditions, extra attention is given to ensuring the concrete mix is durable and resistant to environmental factors. The concrete placement process will be handled manually.

### 3.11 Concrete Mixes

Mixes are designed using IS 10262:2019 and IS 456:2000. Paper plastic aggregates replace coarse aggregates in various proportions to achieve the required strength and workability.

### 3.12 Selection of Water-Cement Ratio

The water-cement ratio is set at 0.45, below the maximum allowed ratio of 0.50, ensuring adequate mix quality.

## 4. RESULTS AND DISCUSSION

To determine the strength characteristics of concrete cubes containing different amounts of paper plastic particles, a number of tests were conducted on the concrete specimens. The test results are covered in this chapter. Results are obtained using substantial testing, such as the Compressive, Split Pliable, and Flexural tests.

### 4.1 Compression Strength

Cement's compressive strength is its primary characteristic. The compressive strength of cement serves as a foundation for evaluating the various properties of the material. In order to confirm the goal's strength, the solid shape compressive strength of the considerable blends was assessed after 7 days, and the results were finished after 28 days. It has been observed that as paper plastic content increases. The compressive strength of aggregate deteriorates with age. Compression testing was performed on cube specimens, and the ultimate compression strength was ascertained thanks to the failure load measurement that the compression testing apparatus supplied. The average values of the specimens at 7 and 28 days are recorded for each category.

**Table 1 Observation of Compressive Strength of Conventional Concrete and Paper Plastic Aggregate Concrete (50%) of Grade M25**

| Sl. No | Age of Cube | Cross Sectional Area (mm^2) | Load at Failure (N) | Compressive Strength (N/mm^2) | Average Compressive Strength (N/mm^2) | Load at Failure(N) | Compressive Strength (N/mm^2) | Average Compressive Strength (N/mm^2) |
|---|---|---|---|---|---|---|---|---|
| 1 | 7 Days | 22500 | 227.0 | 10.08 | | 205.3 | 9.12 | |
| 2 | 7 Days | 22500 | 252.0 | 11.2 | 10.73 | 220.9 | 10.8 | 10.44 |
| 3 | 7 Days | 22500 | 245.6 | 10.91 | | 233.2 | 11.4 | |
| 4 | 28 Days | 22500 | 524.25 | 23.3 | | 403.1 | 19.71 | |
| 5 | 28 Days | 22500 | 560.33 | 24.9 | 24 | 492 | 21.86 | 21. 3566 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | 28 Days | 22550 | 535.58 | 23.8 | | 506.4 | 22.5 | |

**Table 2 Observations of Compressive Strength of Strength Of Paper Plastic Aggregate Concrete (75% & 100%) Of Grade M25**

| Sl. No | Age of Cube | Cross Sectional Area (mm^2) | Load at Failure (N) | Compressive Strength (N/mm^2) | Average Compressive Strength (N/mm^2) | Load at Failure (N) | Compressive Strength (N/mm^2) | Average Compressive Strength (N/mm^2) |
|---|---|---|---|---|---|---|---|---|
| 1 | 7 Days | 22500 | 128.9 | 5.32 | 5.976 | 103.7 | 4.28 | 4.92 |
| 2 | 7 Days | 22500 | 143.2 | 5.91 | | 121.9 | 5.03 | |
| 3 | 7 Days | 22500 | 162.3 | 6.7 | | 132.1 | 5.45 | |
| 4 | 28 Days | 22500 | 349.6 | 14.43 | 15.11 | 249.7 | 10.3 | 11.2 |
| 5 | 28 Days | 22500 | 365.8 | 15.1 | | 278.7 | 11.5 | |
| 6 | 28 Days | 22550 | 382.97 | 15.81 | | 282.1 | 11.64 | |

### 4.2 Split Tensile Strength

Since tensile breaking in the material can be caused by structural loads, "tensile strength" is one of the most important properties of concrete. Tensile strength in concrete is significantly less than compressive strength. It is believed that the tensile strength of concrete is roughly 10% more than the compressive strength. Indirect approaches are employed to determine the tensile strength because the direct approach presents challenges. It calculates the maximum stress at the tension face of an unreinforced concrete beam or slab where bending fails.

**Table 3 Observations of Tensile Strength of Conventional Concrete and Paper Plastic Aggregate Concrete (50%) of Grade M25**

| Sl. No | Age of Cube | Tensile Strength (Mpa) | Average Tensile Strength (N/mm^2) | Tensile Strength(Mpa) | Average Tensile Strength (N/mm^2) |
|---|---|---|---|---|---|
| 1 | 7 Days | 1.31 | 1.423 | 1.2 | 1.32 |
| 2 | 7 Days | 1.95 | | 1.37 | |
| 3 | 7 Days | 1.91 | | 1.39 | |
| 4 | 28 Days | 4.99 | 4.933 | 2.98 | 3.07 |
| 5 | 28 Days | 4.72 | | 3.02 | |
| 6 | 28 Days | 5.09 | | 3.21 | |

**Table 4 Observations of Tensile Strength of Paper Plastic Aggregate Concrete (75% & 100%) Of Grade M25.**

| Sl. No | Age of Cube | Tensile Strength (Mpa) | Average Tensile Strength (N/mm^2) | Tensile Strength (Mpa) | Average Tensile Strength (N/mm^2) |
|---|---|---|---|---|---|
| 1 | 7 Days | 0.68 | 0.716 | 0.37 | 0.393 |
| 2 | 7 Days | 0.72 | | 0.4 | |
| 3 | 7 Days | 0.75 | | 0.41 | |
| 4 | 28 Days | 1.5 | 1.55 | 0.94 | 1.023 |
| 5 | 28 Days | 1.54 | | 1.05 | |
| 6 | 28 Days | 1.61 | | 1.08 | |

**4.3 Flexural Test on Concrete**

Tensile strength of concrete can be indirectly assessed through the use of flexural testing. It evaluates a concrete slabs or beam's resistance to bending failure in the absence of reinforcement. The modulus of rupture (MR), expressed in MPa or psi, indicates the outcome of a flexural test conducted on concrete.

**Table 5 Observation Of Flexural Strength (Mpa) In Conventional Concrete And Paper Plastic Aggregate Concrete.**

| % Of Paper Plastic Aggregate | Sample | 7 Days | Average Flexural Strength (MPa) | 28 Days | Average Flexural Strength (MPa) |
|---|---|---|---|---|---|
| 50% | 1 | 4.6 | 4.6 | 14 | 15 |
| | 2 | 4.6 | | 16 | |
| 100% | 1 | 2.71 | 2.765 | 9.0 | 9.9 |
| | 2 | 2.82 | | 10.8 | |

The Average 7- Days and 28-Days Strength for 50% Paper Plastic Aggregate Concrete is replaced is 4.6 N/mm^2and 15 N/mm^2.

The Average 7- Days and 28-Days Strength for 100% Paper Plastic Aggregate Concrete is replaced is 2.765 N/mm^2 and 9.9 N/mm^2.

**5. CONCLUSION**

This study evaluates the use of paper-plastic aggregate (PPA) as a substitute for coarse aggregate in lightweight concrete, which has diverse applications. While lightweight concrete has been used for centuries, questions remain, and this review examines key aspects like aggregate properties, mix design, and testing. The inclusion of PPA in concrete reduces plastic waste, contributing to environmental sustainability by lowering pollution. PPA can improve sound and thermal insulation but results in lower structural performance due to its lower density. A 50% PPA replacement achieves comparable compressive strength to traditional concrete after 28 days, but further increases reduce workability and strength. The research highlights PPA’s potential for non-structural applications, its environmental benefits, and the possibility of producing low-cost, sustainable concrete.

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