COMPARATIVE ANALYSIS OF COMPRESSIVE STRENGTH BETWEEN EXPANDED POLYSTYRENE (EPS) CONCRETE AND REGULAR CONCRETE

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering



Department of Civil Engineering

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Section- 24B+24D

Spring- 2025

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BOARD OF EXAMINERS

The candidates have exhibited exceptional proficiency and excellence, surpassing the rigorous criteria established by the Board of Examiners. Consequently, they have been conferred with the Degree of Bachelor of Science in Civil Engineering on Defense Date: 17 May 2025. Their research on "Comparative Analysis of Compressive Strength between Expanded Polystyrene (EPS) Concrete and Regular Concrete" presented during the degree ceremony exemplifies commendable academic achievement.

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DECLARATION

We, the undersigned students enrolled in the Civil Engineering Department, Section 24B + 24D, Semester Year 2025, at Sonargaon University, affirm that our thesis titled "Comparative Analysis of Compressive Strength between Expanded Polystyrene (EPS) Concrete and Regular Concrete" represent our original work. The authenticity of the data, analysis, and conclusions presented herein is guaranteed, having not been previously submitted for any academic purpose. We express gratitude to all sources and references consulted during the research process.

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Dedicated

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This dedication celebrates the remarkable dedication and selflessness of our teachers, whose passion for education ignites a flame within us. Their unwavering commitment to nurturing our minds and shaping our futures fills our hearts with gratitude and inspires us to strive for excellence.

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ABSTRACT

This study presents a comparative analysis of compressive strength in concrete utilizing Expanded Polystyrene (EPS) bubbles as partial percentage of coarse aggregates. The mechanical and durability properties of concrete incorporating expanded polystyrene bubbles as partial replacements for natural coarse aggregate are investigated. By partially replacing the fine aggregate with polystyrene bubbles, lightweight concrete with structural integrity and ease of handling is achieved, aligning with project specifications. Polystyrene, a lightweight material widely used in various technological applications, offers potential for producing non-structural concrete. Experimental investigations were conducted, encompassing preliminary material tests and evaluations of compressive strength across varying densities of polystyrene aggregate concrete. The aim was to elucidate the relationships between engineering characteristics and performance. With growing demand for construction materials and a focus on reducing dead weight in taller structures, substituting polystyrene beads for fine coarse particles in concrete foundations is proposed. The primary objective is to identify concrete mix proportions that yield performance akin to foam concrete in the absence of polystyrene beads. Comparative analysis of sixteen concrete types will enable achieving this objective.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The aim of this investigation is to develop a novel lightweight aggregate concrete employing expanded polystyrene aggregate, aiming to significantly diminish structural dead load while enhancing economic feasibility. To achieve this, a total of sixteen concrete mixes were formulated, maintaining a consistent binder content (cement). These sixteen mixes were systematically categorized into four distinct groups based on their respective proportions. Within each group, four sub-mixes were meticulously prepared, substituting fine aggregate with expanded polystyrene aggregate at varying levels. This experimental inquiry scrutinizes the performance of the aforementioned sixteen concrete formulations, both with and without the inclusion of expanded polystyrene aggregate as a partial substitute for fine aggregate. Comprehensive evaluations of compressive strength were conducted to ascertain the efficacy of each concrete mixture. Through this systematic investigation, we endeavor to unveil the optimal composition that balances structural integrity with the advantageous properties of lightweight concrete, thereby offering a promising avenue for cost-effective and sustainable construction practices.

1.2 Objective of the Study

- To enhance sustainability by reducing concrete weight without compromising compressive strength.
- To compare the compressive strength of concrete mixes containing polystyrene bubbles with those containing traditional Coarse aggregates.

1.3 Organization of the Thesis

The organization of the thesis section provides a concise overview of the entire document's structure. It outlines each chapter, including titles and brief descriptions of their contents. This section serves as a roadmap for readers, guiding them through the main themes and topics explored in the thesis.

Chapter 1 : Introduction and Objectives. This chapter provides the background and motivations of the research. The overall objectives and expected outcomes are also described in this chapter.

Chapter 2 : Literature Review. This chapter reviews the related works in the field, with a

special focus on [specific area or topic, e.g., light concrete].

Chapter 3 **:** Methodology. This chapter describes the methodology adopted to carry out the research.

Chapter 4 **:** Results and Discussion. This chapter presents the results of [specific aspect of the research, e.g., Comparative Analysis of Compressive Strength in Concrete Utilizing Polystyrene Bubbles as Partial Fine Aggregate] and discusses their implications.

Chapter 5 **:** Conclusions and Future Work. This chapter summarizes the conclusions drawn from the study and outlines potential avenues for future research. This structure maintains clarity and coherence throughout the thesis, guiding both the writer and the reader through the research process.

CHAPTER 2

LITERATURE REVIEW

2.1 General

This literature review provides a comprehensive overview of research relevant to the thesis objective. It centers on the utilization of expanded polystyrene (EPS) in lightweight concrete production, a topic of growing interest among engineers and environmentalists. Numerous studies have explored the mechanical properties of lightweight concrete incorporating EPS, examining various ratios and assessing durability under different environmental conditions. Additionally, research has delved into the thermal properties of such concrete formulations. By synthesizing findings from these investigations, this chapter lays the groundwork for the current thesis research, which aims to contribute to the understanding of EPS concrete performance and its suitability for diverse applications. Through systematic analysis and review, this chapter underscores the significance of EPS-based lightweight concrete as a potential sustainable solution in construction engineering.

2.2 Review of Different Works

In their seminal work, Ravindra rajah et al. (1994) conducted a rigorous experimental investigation into the effects of water-to-cement ratio on the properties of hardened concrete containing chemically treated expanded polystyrene (EPS) beads. The study focused on concrete with a nominal density of 1300 kg/m³, with the targeted volume fraction of EPS beads set at 40%. The findings underscored a significant impact of EPS inclusion on the mechanical properties of concrete. Specifically, the incorporation of EPS resulted in a notable reduction in both compressive and tensile strengths of the concrete matrix. Notably, the study highlighted the pivotal role of the water-to-cement ratio in governing the mechanical performance of polystyrene concrete. A key revelation was that minimizing the water-to-cement ratio was imperative for achieving optimal strength characteristics. The study demonstrated that a reduction in the water-to-cement ratio from 0.60 to 0.35 led to a substantial enhancement in the 28-day compressive strength of polystyrene concrete, escalating from 5.6 MPa to
11.9 MPa. Moreover, the investigation elucidated the intricate relationship between water-to-cement ratio and the development of compressive strength over time. Concrete with a lower water-to-cement ratio exhibited a higher proportion of its 28-day strength at the 7-day mark, showcasing superior early- age strength development compared to its counterparts with higher water-to-cement ratios. Interestingly, the study revealed that the influence of water-to-cement ratio on tensile strength mirrored its effect on compressive strength, a departure from the behavior observed in conventional concrete. This deviation emphasized the unique characteristics of polystyrene concrete and underscored the importance of carefully optimizing

the water-to-cement ratio to harness its mechanical properties effectively. Overall, Ravindra rajah et al.'s comprehensive analysis provides invaluable insights into the intricate interplay between water-to-cement ratio, EPS content, and the mechanical behavior of polystyrene concrete, offering practical guidance for optimizing its performance in construction applications.

CHAPTER 3
MATHODOLOGY

3.1 Materials

In selecting materials for any construction project, thorough consideration must be given to their quality, compatibility, and adherence to relevant standards. For instance, when choosing cement, such as Binnani Cement, it's imperative to ensure it meets the necessary grade specifications, in this case, conforming to IS 8112:1989 standards. This ensures reliability and consistency in performance. Consistency is further assured by sourcing materials from the same batch, minimizing potential variations that could affect the structural integrity of the project. Understanding the physical properties and chemical composition of the chosen material, in this case, Portland cement, is crucial for predicting its behavior in different environmental conditions and ensuring it meets the project's requirements. It's essential to consider factors such as availability and local market conditions to ensure a smooth procurement process without compromising on quality. By prioritizing quality materials that meet established standards and are suitable for the intended application, construction projects can achieve durability, safety, and longevity. Thus, meticulous attention to material selection is fundamental for the success and longevity of any construction endeavor.

3.1.1 Concrete

Concrete, the ubiquitous building material, stands as a testament to human ingenuity and engineering prowess. Second only to water in its global consumption, concrete is a cornerstone of modern civilization, shaping the skylines of cities and the infrastructure that connects them. Yet, behind its seemingly simple composition lies a complex interplay of materials, chemistry, and construction techniques that have evolved over centuries. At its core, concrete is a blend of four primary ingredients: coarse aggregates, fine aggregates, binding materials, and water. These components come together in a delicate dance to create a substance that transitions from a pliable paste to a solid stone-like structure. The coarse aggregates provide bulk and strength, while the fine aggregates fill in the gaps, and the binding materials, such as Portland cement, hold everything together. Water acts as the catalyst, initiating a chemical reaction known as hydration, which transforms the mixture into a hardened mass. In its nascent form, freshly mixed concrete, often referred to as green concrete, holds the promise of limitless possibilities. Its fluidity allows it to be molded and shaped into virtually any form, making it a versatile medium for construction projects of all scales.

The advent of reinforced concrete in the late 19th century, pioneered by French gardener Joseph Monier, revolutionized structural engineering, enabling the construction of taller buildings, longer bridges, and more resilient infrastructure. This newfound versatility was exemplified by

iconic structures like the Hoover Dam and the Empire State Building, which showcased the material's strength and durability on a grand scale. As the 20th century unfolded, concrete technology continued to evolve, driven by advancements in materials science and construction techniques. Researchers and engineers began exploring alternative materials and methodologies to enhance the performance and sustainability of concrete structures. One such innovation is the incorporation of lightweight aggregates, such as expanded polystyrene foam (EPS), into concrete mixtures, with its low density, thermal insulation properties, and versatile nature, EPS emerges as a promising contender in the pursuit of sustainable construction solutions, poised to shape the skylines of tomorrow. In the modern era, the quest for sustainable and resilient infrastructure has propelled concrete innovation to new heights. From self-healing concrete that repairs cracks autonomously to carbon-negative concrete that sequesters CO2 emissions, the future of concrete holds boundless possibilities for shaping a more sustainable built environment.

3.1.2 Classification of Concrete

Concrete, the cornerstone of modern construction, comes in various forms, each tailored to specific needs and conditions. One crucial aspect of concrete classification lies in its unit weight, which determines its applications and characteristics. Let's delve into the three primary classifications: -

Heavy Concrete

Unit Weight Range **:** 3200 kg/m³ - 4000 kg/m³

Usage : Primarily employed in specialized environments such as nuclear reactors.

Characteristics **:** This dense concrete variant offers exceptional durability and radiation shielding properties, crucial for containing nuclear materials and ensuring structural integrity in high-risk settings.

Normal Concrete

Unit Weight Range **:** 2400 kg/m³ - 2600 kg/m³

Usage **:** Widely utilized in general construction applications, including residential, commercial, and industrial projects.

Characteristics **:** Offering a balance between strength, cost-effectiveness, and workability, normal concrete forms the backbone of most construction endeavors. Its versatility and reliability make it a staple choice across various industries.

Lightweight Concrete

Unit Weight **:** Less than 2000 kg/m³

Usage **:** Ideal for projects where weight reduction is paramount, such as upper floors, precast elements, and insulation.

Characteristics **:** Despite its lower density, lightweight concrete maintains adequate strength and thermal insulation properties. Its reduced

weight facilitates easier handling, transportation, and installation, contributing to overall project efficiency and sustainability.

Understanding the classification of concrete is crucial for selecting the right material for specific construction needs. Whether it's the robustness of heavy concrete, the versatility of normal concrete, or the lightweight benefits of its counterpart, each variant plays a vital role in shaping the built environment. By matching concrete types to project requirements, engineers and builders ensure optimal performance, longevity, and safety in every structure they erect.

3.1.3 Cement

Cement, a fundamental ingredient in concrete, encompasses a diverse range of binders crucial for construction and building projects. Among these, Portland cement reigns supreme, constituting the bulk of contemporary concrete formulations. Formulated through the pulverization of gypsum and Portland cement clinker—derived from the calcination of appropriate blends of calcareous and clayey materials—Portland cement boasts hydraulic properties vital for concrete cohesion. The amalgamation of cement with water engenders "cement paste," pivotal for concrete's structural integrity. This paste fulfills multiple roles within the concrete matrix: enveloping aggregate surfaces, bridging interstitial gaps, and fostering cohesion among aggregate particles. Through binding these constituents, cement paste facilitates the creation of a dense, durable concrete mass. Portland cement's versatility arises from its capacity to adapt to diverse construction needs. Its chemical composition, though variable, consistently delivers the requisite strength, durability, and workability demanded by modern construction standards. Moreover, its hydraulic nature allows for robust performance in varied environmental conditions, ensuring concrete structures withstand the test of time. In essence, cement serves as the linchpin in concrete formulation, providing the adhesive properties essential for structural integrity. Its evolution and refinement over centuries have propelled the advancement of construction methodologies, enabling the realization of architectural marvels worldwide. As innovation continues to drive material science forward, cement remains a cornerstone of the built environment, anchoring the foundations of progress and development.



Figure: 3.1.3.1 Cement

3.1.4 Water

Materials play a pivotal role in ensuring the quality and integrity of any project. In construction, for instance, the selection and specification of materials are critical for durability and safety. Compliance with relevant standards such as IS: 456-2000 for water quality is paramount to meet regulatory requirements and maintain consistency in results. It ensures that the water used for mixing and curing adheres to established norms, thereby contributing to the structural strength and longevity of the construction. Attention to detail in material selection underscores a commitment to quality and reliability, mitigating risks associated with substandard inputs. Ultimately, adherence to specified standards enhances the project's overall performance and resilience, safeguarding against potential structural deficiencies and ensuring long-term sustainability.



Figure: 3.1.4.1 Water

3.1.5 Fine aggregate

The sand utilized in the experimental program was locally sourced and adhered to Bangladesh Standard Specifications. To ensure uniformity, the sand underwent an initial sieving process using a 4.75 mm sieve to eliminate particles larger than 4.75 mm, followed by a thorough washing to eliminate any dust particles. Detailed properties of the fine aggregate employed in the experimental investigation are systematically tabulated for reference. This meticulous preparation of the fine aggregate guarantee's consistency and accuracy in subsequent experimental procedures, thereby enhancing the reliability of the research outcomes. Adhering to standardized procedures for material preparation is critical in ensuring the validity and reproducibility of experimental findings, thus maintaining the integrity of the research endeavor.



Figure: 3.1.5.1 Sample Fine Aggregate.

A. Fineness Modulus Test

The term 'sieve analysis' is the sample operation of dividing a sample of aggregates into fractions each consisting of particles between specific limits. The analysis is conducted to determine the grading of material proposed for use as aggregates. The term Fineness Modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the standard sieves and dividing this sum arbitrarily by 100. No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8 in., ¾ in., 1.5 in. and 3in. are the ASTM standard sieves. This test method conforms to the ASTM standard requirements of specification C136.

Fine Aggregate

The test sample of the aggregate (F.M) shall weigh, after drying, approximately the following requirement:

Aggregate with at least 85% passing No. 4 Sieve And more than 5% retained on a No. 8 Sieve.



Figure: 3.1.5.2 Sample Fine Aggregate FM Test

Table 3.1.5.A: Sieve Analysis of Fine Aggregate

Sieve Number	Sieve Size Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % Retained	Percent Finer
4	4.75	16	1.6	1.6	98.4
8	2.36	70	7	8.6	91.4
16	1.19	364	36.4	45	55
30	0.59	307	30.7	75.7	24.3
50	0.3	196	19.6	95.3	4.7
100	0.15	38	3.8	99.1	0.9
Pan		9			
		1000		325.3	

Fineness modulus of fine Aggregate = (ΣF/100)
= (325.3/100)
= 3.25

B. Specific Gravity Test

Aggregates generally contain pores, both permeable and impermeable, for which specific gravity has to be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required in calculating the compacting factor in connection with workability measurements. This test method covers the determination of bulk and apparent specific gravity, 23/230C (73.4/72.40F) and absorption capacity of fine aggregate. This is used for I) calculation of the volume occupied by the

aggregate of varying mixtures on an absolute volume basis, ii) the computation of voids in aggregate and iii) the determination of moisture in aggregate. The specific gravity of a porous solid, when the volume of the solid as used in the calculation includes both the permeable and impermeable voids. Bulk Specific Gravity (also known as Bulk Dry Specific Gravity) is the ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas free distilled water at the stated temperature. Apparent specific gravity is the ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at the stated temperature.



Figure: 3.1.5.3 Specific Gravity Test of Fine Aggregate

Table 3.1.5.B: Specific Gravity of Fine Aggregate

Specific Gravity and Absorption Capacity of Fine Aggregate			
Data Sheet			
Wt. of Pycnometer Filled with Water to Calibration mark. **B gm**	Oven Dry Wt. in Air **A gm**	Wt. of Pycnometer with Specimen and Water to Calibration mark. **C gm**	Wt. of S.S.D. sample in Air. **S gm**
657	293	840	300

Test	**Formula**	**Result**
Apparent Specific Gravity	**=A/(B+A-C)**	2.66
Bulk Specific Gravity (Oven Dry Basis)	**=A/(B+S-C)**	2.50
Absorption Capacity, D%	**=(S-A)/A*100**	2.39
Bulk Specific Gravity (S.S.D. Basic), G	**=S/(B+S-C)**	2.56

C. Unit Weight of Fine Aggregate

This test method covers the determination of unit weight in a compacted or loose condition of fine and coarse aggregates. Unit weight values of aggregates are necessary for use in many methods of selecting proportions for concrete mixtures. They may also be used for determining mass/volume relationships for conversions and calculating the percentages of voids in aggregates. Voids inside particles, either permeable or impermeable, are not included in 'Voids' as determine by this test method. This test method conforms to the ASTM standard requirements of specification C29.



Figure: 3.1.5.4 Unit Weight Test Work of Fine Aggregate.

Table 3.1.5.C : Unit Weight of Fine Aggregate

Unit Weight of Fine Aggregate					
Data Sheet					
Volume of Bucket (CuM)			**0.00278**		
Condition Name	**Volume of Bucket (gm)**	**Volume of Bucket + Materials (gm)**	**Volume of Materials (gm)**	**Volume of Bucket (gm)**	**Unit Wright of Materials (gm)**
Shoveling	4000	8005	4005	0.00278	1441
Rodding	4000	8485	4485	0.00278	1613
Jiggling	4000	8499	4499	0.00278	1618
			Average Unit Weight		**1557**

3.1.6 Coarse aggregate

Materials selection is crucial in any project, and the choice of coarse aggregate plays a significant role. The nature of the task dictates the maximum size of the coarse aggregate. In our project, locally available coarse aggregate with a maximum size of 12 mm was employed. To ensure quality, the aggregates underwent thorough washing to eliminate dust and dirt, followed by drying to achieve a surface dry condition. This meticulous preparation guarantees

the integrity and performance of the coarse aggregate in the construction process. By adhering to these standards, we ensure optimal structural strength and durability, laying a solid foundation for the successful completion of the project.



Figure: 3.1.6.1 Sample of Coarse Aggregate.

A. Fineness Modulus Test

The term ‘sieve analysis’ is the sample operation of dividing a sample of aggregates into fractions each consisting of particles between specific limits. The analysis is conducted to determine the grading of material proposed for use as aggregates. The term Fineness Modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the standard sieves and dividing this sum arbitrarily by 100. No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, 3/8 in., ¾ in., 1.5 in. and 3in. are the ASTM standard sieves. This test method conforms to the ASTM standard requirements of specification C136.

Coarse aggregate

The weight of the test sample of coarse aggregate (C.A) shall conform to the following requirements:

Aggregates with nominal maximum size of 3⁄4 in. 10 lbs.



Figure: 3.1.6.2 Sample Coarse Aggregate FM Test.

Table 3.1.6.A: Sieve Analysis of Coarse Aggregate

Sieve Analysis of Coarse Aggregate					
Sieve Number	**Sieve Opening (mm)**	**Materials Retained (gm)**	**% Materials Retained**	**Cumulative % Retained**	**Percent Finer**
3/4"	19.05	73	3.65	3.65	96.35
3/8"	9.5	1607	80.35	84	16
4	4.75	320	16	100	0
8	2.36	0	0	100	0
16	1.19	0	0	100	0
30	0.95	0	0	100	0
50	0.3	0	0	100	0
100	0.15	0	0	100	0
		2000		687.65	
FINENESS MODULUS (F.M.) =				6.87	

Fineness modulus of Coarse Aggregate = (ΣF/100)
= (687/100)
= 6.87

B. Specific Gravity Test

This test method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk specific gravity, bulk specific gravity (saturated-surface-dry (SSD)), or apparent specific gravity. The bulk specific gravity (SSD) and absorption are based on aggregate after 15 hours soaking in water. All the terminology and their uses are same as for the specific gravity and absorption of fine aggregate.




Figure: 3.1.6.3 Specific Gravity Test Work of Coarse Aggregate.

Table 3.1.6.B Specific Gravity of Coarse Aggregate

Specific Gravity and Absorption Capacity of Fine Aggregate			
Data Sheet			
Wt. of Pycnometer Filled with Water to Calibration mark. **B gm**	Oven Dry Wt. in Air **A gm**	Wt. of Pycnometer with Specimen and Water to Calibration mark. **C gm**	Wt. of S.S.D. sample in Air **S gm**
1545	1525	1000	0

Test	**Formula**	**Result**
Apparent Specific Gravity	**=A/(A-C)**	2.90
Bulk Specific Gravity (S.S.D. Basic), G	**=B/(B-C)**	2.83
Bulk Specific Gravity (Oven Dry Basis)	**=A/(B-C)**	2.80
Absorption Capacity, D%	**=(B-A)/(A*100)**	1.31

C. Unit Weight

This test method covers the determination of unit weight in a compacted or loose condition of fine and coarse aggregates. Unit weight values of aggregates are necessary for use in many methods of selecting proportions for concrete mixtures. They may also be used for determining mass/volume relationships for conversions and calculating the percentages of voids in

aggregates. Voids inside particles, either permeable or impermeable, are not included in 'Voids' as determine by this test method. This test method conforms to the ASTM standard requirements of specification C29.



Figure: 3.1.6.4 Unit Weight Test of Coarse Aggregate.

Table 3.1.6.C: Specific Gravity of Coarse Aggregate

Unit Weight of Coarse Aggregate					
Data Sheet					
Volume of Bucket (CuM)			**0.00278**		
Condition Name	**Volume of Bucket (gm)**	**Volume of Bucket + Materials (gm)**	**Volume of Materials (gm)**	**Volume of Bucket (gm)**	**Unit Wright of Materials (gm)**
Shoveling	4000	7879	3879	0.00278	1395
Rodding	4000	8430	4430	0.00278	1594
Jiggling	4000	8501	4501	0.00278	1619
			Average Unit Weight (gm)		1536

3.1.7 Light Weight Concrete

Lightweight concrete, often referred to as cellular or foam concrete, is a versatile construction material known for its reduced density and enhanced thermal insulation properties. It finds extensive applications in various sectors due to its lightweight nature, which can significantly reduce structural dead loads, leading to cost savings in construction projects. One notable example of a lightweight concrete mix is composed of Portland cement, sand, water, and lightweight aggregates such as expanded clay, shale, or slate. In the production of lightweight concrete, the incorporation of lightweight aggregates plays a pivotal role. These aggregates are typically manufactured by expanding or bloating natural materials, resulting in a porous structure that reduces overall density while maintaining adequate strength. Similarly, expanded shale and slate aggregates are manufactured using similar techniques, offering lightweight alternatives to traditional heavy aggregates like gravel or crushed stone. The lightweight aggregates are combined with cement, sand, and water to create a lightweight concrete mix. The proportion of each component can be adjusted to achieve desired properties such as compressive strength, density, and thermal insulation. The resulting concrete mixture exhibits excellent workability, allowing for easy placement and finishing during construction. One of the primary advantages of lightweight concrete is its superior thermal insulation properties. The porous structure of the lightweight aggregate's traps air within the concrete, creating a barrier against heat transfer. This thermal insulation capability helps regulate indoor temperatures,

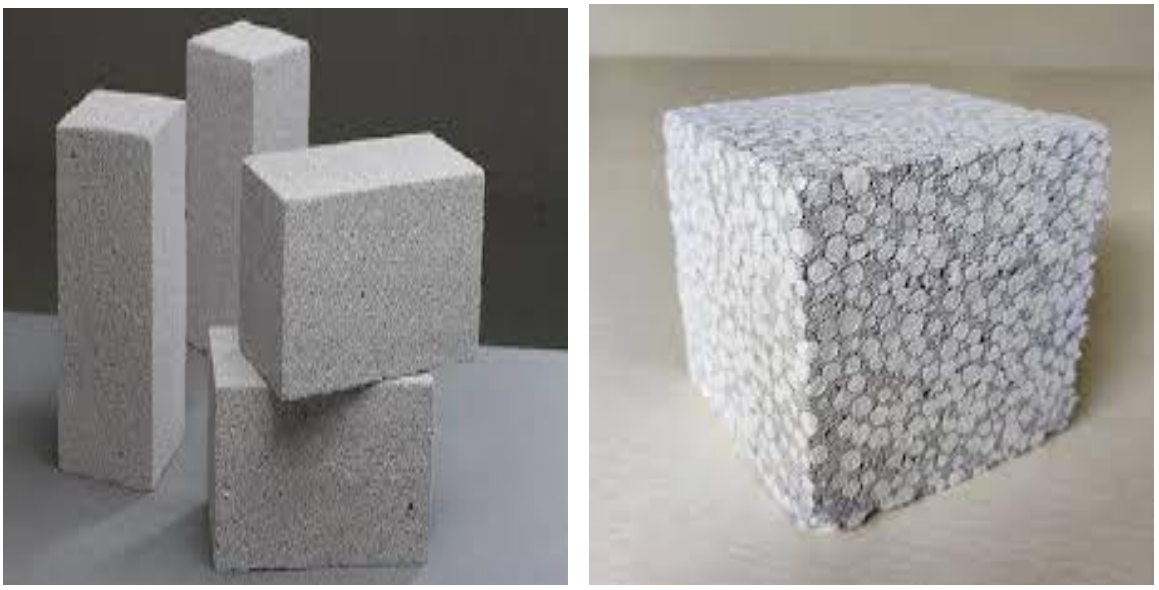


Figure:3.1.7.1 Lightweight Concrete.

reducing the need for heating and cooling systems and contributing to energy efficiency in buildings.

Moreover, lightweight concrete offers benefits in terms of seismic performance, as its reduced weight can lessen the inertia forces during earthquakes, enhancing structural stability and safety. Additionally, its low density makes it easier to handle and transport, reducing construction time and labor costs.

Lightweight concrete exemplifies an innovative approach to construction materials, offering a blend of strength, durability, and thermal insulation in a lightweight package. Its versatility and sustainability make it a preferred choice for a wide range of applications, from residential buildings to infrastructure projects.

Lightweight concrete, a marvel in construction, offers versatility and efficiency in various applications. Categorized into structural and non-structural variants, its formulation is guided by ACI Committee 213's delineation of three distinct divisions.

(i) Firstly, low-density, low-strength concrete serves as a reliable isolating material, providing essential support while maintaining minimal weight. This variant finds its niche in scenarios where the primary requirement is to reduce the overall load on structures without compromising on durability.

(ii) Secondly, moderate-strength lightweight concrete strikes a balance between strength and weight, rendering it ideal for diverse applications such as concrete blocks. Its utility extends to scenarios where a certain degree of structural robustness is necessary alongside the benefits of reduced mass.

(iii) Lastly, structural lightweight concrete emerges as the pinnacle of this innovation, offering substantial strength while maintaining a significantly lower unit weight compared to conventional counterparts. Its deployment spans a wide spectrum of structural demands, from residential constructions to infrastructure projects.

The evolution of lightweight concrete presents a spectrum of solutions tailored to diverse construction needs, each division offering a unique blend of strength, weight efficiency, and adaptability.

3.1.8 Sample Expanded Polystyrene (EPS)

Polystyrene, a versatile polymer, showcases remarkable properties ideal for various applications. Typically, polystyrene appears as rounded, white solid forms boasting a smooth surface texture. This polymer's structural integrity and aesthetic appeal make it a popular choice across industries. Its lightweight nature coupled with excellent insulation properties renders it invaluable in packaging materials, ensuring product protection during transit. Polystyrene's moldability facilitates intricate designs, enhancing its utility in crafting consumer products and industrial components. Its affordability further underscores its widespread usage, from



Figure: 3.1.8.1 Sample EPS as Coarse Aggregate.

disposable cutlery to insulation panels. Despite its prevalent use, efforts towards sustainable alternatives are imperative, considering polystyrene's environmental impact. Its unparalleled

combination of properties continues to make it a staple material in modern manufacturing processes.

Expanded Polystyrene (EPS) has a compressive strength range of 10 to 60 psi (pounds per square inch) at 10% deformation. This makes it suitable for various applications requiring insulation and load-bearing. The compressive strength can be adjusted by varying the density of the EPS.
Elaboration:

- **Density and Strength**

  The compressive strength of EPS is directly related to its density. Higher density EPS generally exhibits greater compressive strength.

- **Specific Applications**

  EPS with different compressive strengths can be chosen based on the specific application. For instance, EPS with a higher compressive strength might be used for load-bearing applications like under-slab or below-grade insulation, while lower compressive strength EPS might be suitable for applications where weight and cost are more critical.

- **Resilience**

  Besides compressive strength, the resilience of EPS is important, as it indicates the material's ability to recover its shape after being subjected to compressive forces.

- **Variations**

  While 10-60 psi is a common range, it's important to note that specific EPS products and applications might have different compressive strength requirements. For example, some EPS products might have compressive strengths of 70 kPa (10 psi), 90 kPa (13 psi), or even higher.

- **ASTM Standards**
  ASTM D1621 is a standard test method for determining the compressive strength of rigid cellular plastics, including EPS. This standard helps ensure consistent testing and performance data.

CHAPTER 4
RESULT AND DISCUSSIONS

4.1 Introduction

In this segment, we delve into the testing, results, and ensuing discussions pertaining to our experiment. Our primary focus centers on examining the fresh and mechanical properties of PS concrete, coupled with its resilience against sulphate attack. As we embark on this journey of analysis, our aim is to unravel the intricate details encapsulating the performance of PS concrete under varied conditions. We meticulously conducted a series of tests to gauge its behavior, meticulously documenting every nuance for comprehensive understanding. Through rigorous experimentation, we have amassed a wealth of data illuminating the intricacies of PS concrete's properties. Our results not only shed light on its immediate characteristics but also offer insights into its long-term durability, particularly in the face of sulphate attack—a critical aspect in evaluating its practical utility. Our discussions are poised to unravel the underlying mechanisms dictating these observed phenomena. By juxtaposing theoretical frameworks with empirical evidence, we aim to forge a holistic understanding, fostering informed decision-making in the realm of concrete engineering. In essence, this chapter serves as a beacon, guiding readers through the labyrinth of testing, results, and discussions, ultimately illuminating the nuanced landscape of PS concrete performance.

4.2 Testing plan

Thesis Topic : Comparative Analysis of Compressive Strength between Expanded Polystyrene (EPS) Concrete and Regular Concrete.

Use 4.75mm polystyrene bubbles as fine aggregate and 9.5mm Stone chips as Coarse aggregate.

	Test Plan for Regular Concrete								
SL. No	**Grade Name**	**Nominal mix**	**Fine & Coarse Aggregate**	**W/C Ratio**	**Cylinder Age Day's**	**Compressive strength (psi)**	**Average compressive strength (psi)**	**Weight of Cylinder**	**Average Unit Weight**
1	RC-A7	1:2:4	100%	0.46	7				
2					7				
3					7				
4	RC-A21	1:2:4	100%	0.46	21				
5					21				
6					21				
7	RC-A28	1:2:4	100%	0.46	28				
8					28				
9					28				
10	RC-B7	1:1.5:3	100%	0.46	7				
11					7				
12					7				
13	RC-B21	1:1.5:3	100%	0.46	21				
14					21				
15					21				
16					28				

17	RC-B28	1:1.5:3	100%	0.46	28				
18					28				
1	EPSC-A7	1:2:4	25% : 75%	0.46	7				
2					7				
3					7				
4	EPSC-A21	1:2:4	25% : 75%	0.46	21				
5					21				
6					21				
7	EPSC-A28	1:2:4	25% : 75%	0.46	28				
8					28				
9					28				
10	EPSC-B7	1:2:4	50% : 50%	0.46	7				
11					7				
12					7				
13	EPSC-B21	1:2:4	50% : 50%	0.46	21				
14					21				
15					21				
16	EPSC-B28	1:2:4	50% : 50%	0.46	28				
17					28				
18					28				
19	EPSC-C7	1:2:4	75% : 25%	0.46	7				
20					7				
21					7				
22	EPSC-C21	1:2:4	75% : 25%	0.46	21				
23					21				
24					21				
25	EPSC-C28	1:2:4	75% : 25%	0.46	28				
26					28				
27					28				
28	EPSC-D7	1:1.5:3	25% : 75%	0.46	7				
29					7				
30					7				
31	EPSC-D21	1:1.5:3	25% : 75%	0.46	21				
32					21				
33					21				
34	EPSC-D28	1:1.5:3	25% : 75%	0.46	28				
35					28				
36					28				
37	EPSC-E7	1:1.5:3	50% : 50%	0.46	7				
38					7				
39					7				
40	EPSC-E21	1:1.5:3	50% : 50%	0.46	21				
41					21				
42					21				
43	EPSC-E28	1:1.5:3	50% : 50%	0.46	28				
44					28				
45					28				
46	EPSC-F7	1:2:4	75% : 25%	0.46	7				
47					7				
48					7				
49	EPSC-F21	1:2:4	75% : 25%	0.46	21				
50					21				
51					21				
52	EPSC-F28	1:2:4	75% : 25%	0.46	28				
53					28				
54					28				

Table 4.2.1 Testing Plan.

4.3 Testing

4.3.1 Testing the Coarse Aggregate & Weight measurement of Coarse Aggregate

During the testing of coarse aggregate (CA), precise measurement of its weight is crucial. Accurate weight measurement ensures the reliability of subsequent tests and the overall quality of construction materials. To achieve this, employ a calibrated scale with a suitable capacity to accommodate the range of weights expected for your coarse aggregate samples. Before each



Figure: 4.3.1.1: Weight measurement of Fine Aggregate.

measurement, ensure the scale is properly zeroed to eliminate any potential errors. Handle the coarse aggregate samples carefully to prevent spillage or loss, which could compromise the accuracy of the measurement. Record the weights promptly and consistently according to the testing protocol to maintain consistency and traceability. Regular maintenance and calibration of measuring equipment are essential to uphold the integrity of the testing process and ensure reliable results.

4.3.2 Precision in Polystyrene Weight Measurement Testing

Testing the weight measurement of Polystyrene demands meticulous attention to detail and precision. Polystyrene, known for its lightweight yet durable properties, requires accurate measurement for various industrial applications. Utilizing calibrated instruments such as precision balances or scales ensures reliable results. Prior to testing, it's imperative to establish a controlled environment, minimizing external factors that could influence measurements. Sample preparation, including proper cleaning and drying, is crucial to prevent contaminants that could skew results. During testing, repeatable procedures must be followed meticulously, minimizing errors and ensuring consistency. Post-testing, data analysis should include statistical methods to validate results and identify any anomalies. Through rigorous adherence to these protocols, precise weight measurements of Polystyrene can be attained, enabling confidence in its performance across diverse application.



Figure: 4.3.2.1 Weight measurement of Polystyrene

4.3.3 Proportion of mortar mix in specified proportions

Creating the perfect mortar mix requires a delicate balance of ingredients to achieve optimal performance. Among the essential components are aggregate, water, sand, and a lesser-known yet increasingly popular addition: polystyrene bubbles. Aggregate, typically crushed stone or gravel, provides strength and stability to the mortar, ensuring it can bear loads and resist weathering. Water acts as the catalyst for the chemical reaction that binds the mixture together, forming a solid matrix. Sand, with its fine particles, contributes to the workability and cohesion of the mortar, allowing it to be easily spread and shaped. Introducing polystyrene bubbles into the mix offers several benefits. These lightweight, spherical particles enhance the mortar's insulation properties, making it more energy-efficient and reducing heat loss through walls or structures. Additionally, the bubbles create a overall mixture, reducing the weight on load-bearing structures and potentially decreasing construction costs. Achieving the perfect balance of these components is crucial. Too much or too little of any ingredient can the strength, durability, or workability of the mortar. Therefore, meticulous attention to detail and precise measurements are essential in mortar mixing, ensuring the final product meets the required standards for construction excellence.



Figure: 4.3.3.1: Mortar mixing

4.4 Sample Cylinder Casting

To achieve optimal results in creating lightweight concrete blocks using aggregate, sand, water, and polystyrene bubbles, it's crucial to follow specific procedures. Firstly, a proper ratio of materials for desired consistency and strength. The mixture should be fed into the cylinder in layers, compacting each layer adequately to eliminate air pockets and create a dense structure. After each layer, use a tamper or vibrating tool to consolidate the concrete and remove any trapped air, promoting uniformity and strength. Repeat this process until the cylinder is filled to the height. Once filled, the concrete should be piled multiple times to further compress the mixture, enhancing its density and reducing the risk of voids. Each piling should be done carefully, applying consistent pressure to ensure uniform compaction throughout the block.



Figure: 4.4.1 Sample Cylinder Casting

4.5 Curing of Sample

Curing concrete is a crucial step in ensuring its strength, durability, and overall performance. The process involves maintaining adequate moisture and temperature conditions for a specific duration, typically around 28 days, to allow the concrete to achieve its desired properties.

Concrete cylinders are commonly used for testing the compressive strength of concrete. These cylinders are cast in molds and then subjected to a curing process to ensure accurate test results. When curing concrete cylinders in a pot, several factors must be considered to ensure proper curing and optimal strength development. Firstly, the pot used for curing should be clean and free from any contaminants that could affect the curing process or the quality of the concrete. It should also be of sufficient size to accommodate the cylinders without overcrowding, allowing air to circulate around them evenly. Once the cylinders are placed in containers, they should be covered with a waterproof material such as plastic sheeting or submerged in water to prevent moisture loss. This helps to maintain a consistent moisture level within the concrete, which is essential for proper hydration and strength development. The pot should be kept in a controlled environment where temperature and humidity levels can be regulated. Ideally, the temperature should be maintained between 50°F and 75°F (10°C to 24°C), and relative humidity should be kept above 90%. These conditions promote optimal curing and prevent rapid moisture evaporation, which can lead to cracking and reduced strength. During the curing period, it's essential to monitor the moisture content of the concrete regularly. If the surface begins to dry out, additional water may need to be applied to maintain adequate moisture levels. However, care should be taken not to overwater, as excess water can lead to leaching of cementitious materials and weaken the concrete. After the 28-day curing period is complete, the cylinders can be removed from the pot and tested for compressive strength using a hydraulic testing machine. This test involves applying a gradually increasing load to the cylinder until it fails, allowing engineers to determine the maximum compressive strength of the concrete. Curing concrete cylinders in a pot requires careful attention to detail and proper management of environmental conditions. By following the correct procedures and maintaining optimal curing conditions, engineers can ensure that the concrete achieves its desired strength and durability properties.



Figure: 4.5.1 Curing of Sample Concrete Cylinder.

4.6 Sample

To accurately measure the diameter, height, and weight of a cylinder after opening it, one must employ precise techniques and instruments. Firstly, for measuring the diameter, use a caliper or a micrometer to gauge the widest distance across the circular cross-section of the cylinder. Ensure the measurements are taken at multiple points to account for any irregularities. Next, to determine the height, a ruler or a measuring tape can be employed along the vertical axis of the cylinder from the base to the top edge. Again, multiple measurements should be taken to ensure accuracy. As for weight, an accurate scale capable of measuring the weight of the cylinder's contents should be used. After obtaining these measurements, it's crucial to record them meticulously for future reference or analysis. Additionally, exercising caution and precision during the measurement process is essential to avoid errors and ensure the reliability of the data collected.



Figure: 4.6.1 Sample Concrete Cylinder.

4.7 Sample Concrete Cylinder Checking

Before conducting compressive strength tests on cylinders, several factors must be checked to ensure accurate results.

The cylinders' dimensions and surface characteristics should be carefully examined to verify compliance with the specified standards. Any irregularities or defects could significantly affect the test outcomes. The curing conditions of the concrete cylinders must be monitored and confirmed to adhere strictly to the designated curing regime. Curing can lead to variations in strength results. Additionally, the age of the cylinders at the time of testing is crucial, as compressive strength increases with time due to continued hydration. Therefore, testing should be conducted at the appropriate age according to the project specifications. The testing apparatus, including the compression machine and its calibration status, should be checked for accuracy and proper functioning to ensure reliable test results. Environmental conditions such as temperature and humidity during testing should be controlled and recorded to account for any potential influence on the concrete's behavior. By meticulously addressing these factors, the compressive strength testing of cylinders can yield dependable and meaningful results essential for quality assurance in construction projects.



Figure: 4.7.1 Checking Cylinder Soundness for taking Dimension Weight measurement

4.8 Sample Cylinder Measuring and Data Collection

Before conducting any testing on the cylinder, it is imperative to obtain precise measurements of its size to establish a baseline. These measurements serve as a reference point for evaluating any changes that may occur during testing. To accurately measure the size of the cylinder, several parameters must be considered. Its diameter should be measured across its widest point using a caliper or micrometer. This measurement ensures consistency and uniformity throughout the cylinder's structure. The length of the cylinder must be determined, measuring from one end to the other with a ruler or measuring tape. This measurement provides insight into the overall dimensions of the cylinder and helps in calculating its volume. It is crucial to inspect the surface of the cylinder for any irregularities or imperfections that may affect its performance during testing. By meticulously documenting these measurements before conducting any tests, researchers can ensure the accuracy and reliability of their findings.



Figure: 4.8.1 Sample Concrete Cylinder Data Collection by measuring.

4.9 Testing compressive strength

Testing compressive strength is essential in various fields like construction, material science, and engineering. The process involves subjecting a material to force until it collapses or deforms. To ensure accurate results, adhere to standardized testing procedures like ASTM or ISO guidelines. Begin by preparing samples of uniform size and shape. Utilize a reliable testing apparatus such as a universal testing machine. Apply force gradually, recording data at regular intervals until failure occurs. Factors like moisture content, temperature, and loading rate can influence results, so maintain consistent testing conditions. Regular calibration and quality control are crucial to ensure the reliability and repeatability of test results. Understanding and meticulously executing compressive strength testing protocols are fundamental for ensuring structural integrity and safety in diverse industries.



Figure: 4.9.1 Testing compressive strength.

4.10 Analyzing Compressive Strength Data

Compressive strength data provides crucial insights into material durability, essential for construction, engineering, and manufacturing. By testing a material's ability to withstand axial pressure, engineers gauge its structural integrity. The analysis of such data involves meticulous examination and interpretation to inform decision-making processes. Understanding the variations in compressive strength across different materials and under various conditions enables engineers to optimize designs, select appropriate materials, and ensure safety standards. Statistical methods like regression analysis help identify trends and predict performance under different scenarios. Compressive strength data plays a pivotal role in quality control processes, ensuring compliance with industry standards and specifications.



Figure: 4.10.1 Sample Cylinder compressive strength test by (UTM)

4.11 Results

4.11.1 Table

Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= πd²/4 (in²)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
RC-B7	1:1.5:3	100%	0.46	101.31	3.99	205	8.07	4043	4072	7	126	12.49	2266.93	2320.02
				102.65	4.04	206	8.11	4074		7	140	12.83	2453.48	
				101.52	4.00	206	8.11	4100		7	125	12.55	2239.65	
EPSC-D7	1:1.5:3	25% : 75%	0.46	101.93	4.01	207	8.15	3600	3602	7	80	12.65	1421.87	1524.81
				101.81	4.01	206	8.11	3532		7	85	12.62	1514.30	
				103.48	4.07	205	8.07	3675		7	95	13.04	1638.26	
EPSC-E7	1:1.5:3	50% : 50%	0.46	103.69	4.08	206	8.11	3089	3043	7	53	13.09	910.28	869.71
				101.69	4.00	205	8.07	2969		7	48	12.59	857.15	
				102.62	4.04	207	8.15	3070		7	48	12.82	841.69	
EPSC-F7	1:1.5:3	75% : 25%	0.46	102.15	4.02	206	8.11	2319	2417	7	29	12.70	513.21	594.24
				101.53	4.00	206	8.11	2401		7	34	12.55	609.06	
				101.71	4.00	206	8.11	2532		7	37	12.59	660.46	

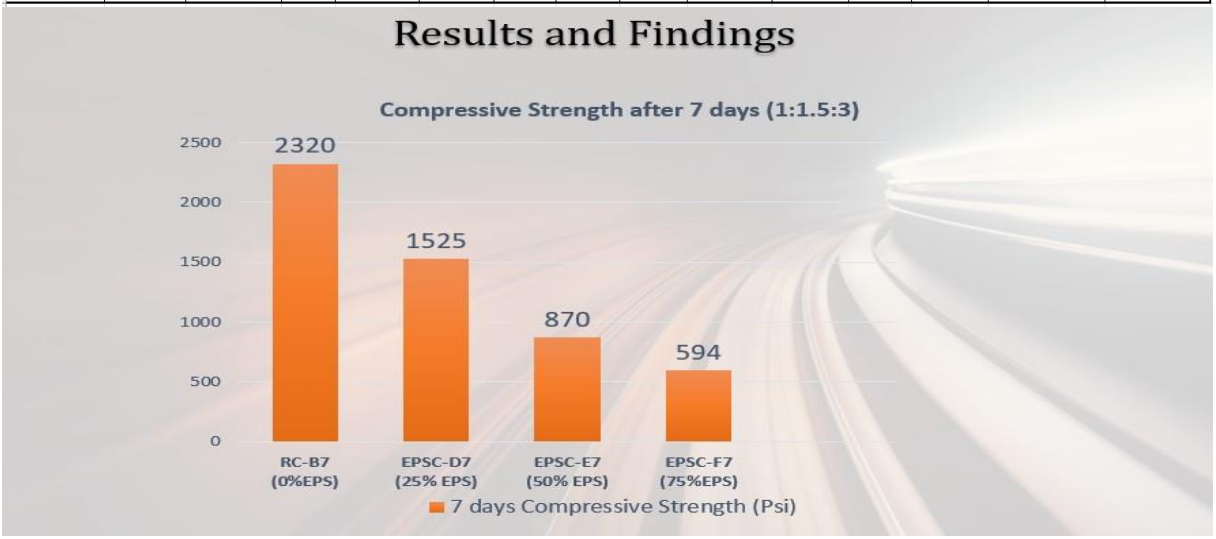


Table: 4.11.1 Sample Data Collection and Result in 7 Days (1:1.5:3).

4.11.2 Table

Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= πd²/4 (in²)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
RC-B21	1:1.5:3	100%	0.46	102.22	4.02	205	8.07	4070	4106	21	178	12.72	3145.73	3144.44
				101.94	4.01	205	8.07	4029		21	167	12.65	2967.56	
				102.80	4.05	207	8.15	4219		21	190	12.86	3320.02	
EPSC-D21	1:1.5:3	25% : 75%	0.46	102.40	4.03	207	8.15	3683	3585	21	122	12.77	2148.49	2102.16
				102.60	4.04	204	8.03	3478		21	113	12.81	1982.24	
				103.00	4.06	206	8.11	3595		21	125	12.92	2175.75	
EPSC-E21	1:1.5:3	50% : 50%	0.46	103.30	4.07	205	8.07	3050	3025	21	65	12.99	1124.83	1171.46
				103.93	4.09	206	8.11	3026		21	67	13.15	1145.42	
				101.93	4.01	206	8.11	2998		21	70	12.65	1244.13	
EPSC-F21	1:1.5:3	75% : 25%	0.46	102.90	4.05	205	8.07	2448	2557	21	45	12.89	784.79	813.81
				103.91	4.09	206	8.11	2683		21	50	13.14	855.12	
				101.82	4.01	206	8.11	2541		21	45	12.62	801.53	

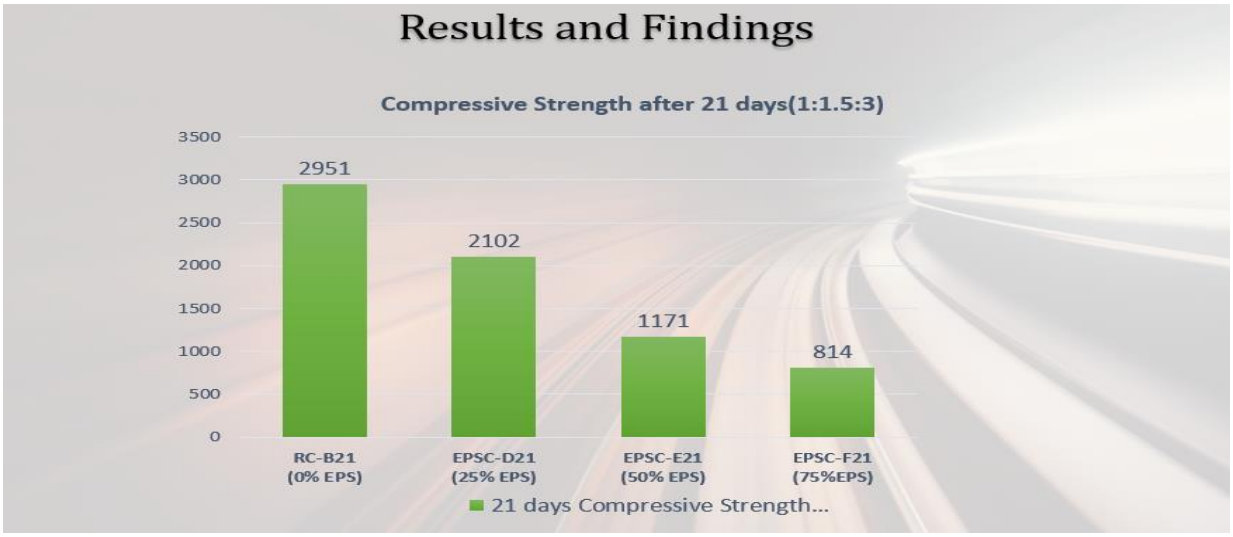


Table: 4.11.2 Sample Data Collection and Result in 21 Days (1:1.5:3).

4.11.3 Table

Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
RC-B28	1:1.5:3	100%	0.46	103.35	4.07	205	8.07	4211	4188	**28**	182	13.00	3146.47	3080.86
				102.80	4.05	204	8.03	4161		**28**	168	12.86	2935.59	
				103.12	4.06	207	8.15	4193		**28**	182	12.95	3160.52	
EPSC-D28	1:1.5:3	25% : 75%	0.46	101.93	4.01	205	8.07	3582	3658	**28**	125	12.65	2221.67	2248.57
				102.29	4.03	204	8.03	3669		**28**	135	12.74	2382.54	
				103.82	4.09	206	8.11	3722		**28**	125	13.12	2141.51	
EPSC-E28	1:1.5:3	50% : 50%	0.46	102.92	4.05	205	8.07	3070	3047	**28**	90	12.90	1568.97	1490.04
				102.88	4.05	206	8.11	3061		**28**	77	12.89	1343.39	
				100.38	3.95	206	8.11	3009		**28**	85	12.27	1557.75	
EPSC-F28	1:1.5:3	75% : 25%	0.46	101.34	3.99	206	8.11	2480	2453	**28**	55	12.50	988.95	862.50
				102.70	4.04	206	8.11	2534		**28**	51	12.84	892.90	
				102.31	4.03	205	8.07	2345		**28**	40	12.74	705.66	

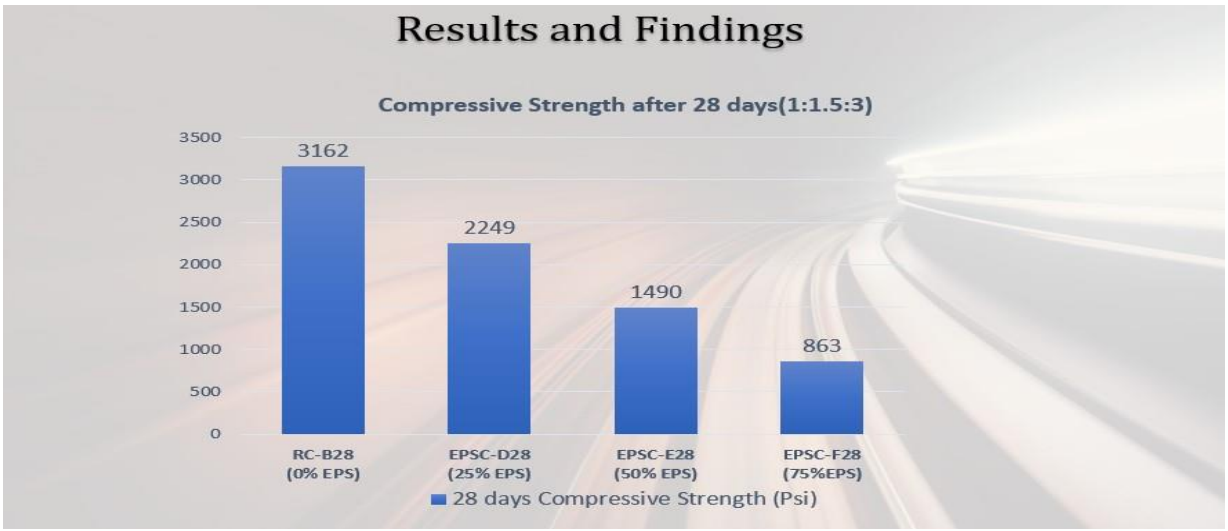


Table: 4.11.3 Sample Data Collection and Result in 28 Days (1:1.5:3).

4.11.4 Table

SL. No.	Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
1	RC-A7	1:2:4	100%	0.45	104.07	4.10	207	8.15	4242	4209	7	112	13.18	1909.59	1964.01
2					103.43	4.07	206	8.11	4220		7	112	13.02	1933.29	
3					101.80	4.01	206	8.11	4166		7	115	12.62	2049.16	
4	EPSC-A7	1:2:4	25% : 75%	0.46	102.55	4.04	207	8.15	3612	3590	7	65	12.80	1141.34	1117.42
5					101.89	4.01	205	8.07	3498		7	60	12.64	1067.24	
6					103.23	4.06	207	8.15	3660		7	66	12.97	1143.68	
7	EPSC-B7	1:2:4	50% : 50%	0.46	102.35	4.03	207	8.15	2948	2922	7	36	12.75	634.60	634.10
8					102.50	4.04	206	8.11	2898		7	32	12.79	562.44	
9					102.34	4.03	206	8.11	2920		7	40	12.75	705.25	
10	EPSC-C7	1:2:4	75% : 25%	0.46	100.73	3.97	207	8.15	2261	2313	7	22	12.35	400.39	429.90
11					101.49	4.00	207	8.15	2312		7	24	12.54	430.27	
12					102.27	4.03	206	8.11	2367		7	26	12.73	459.04	

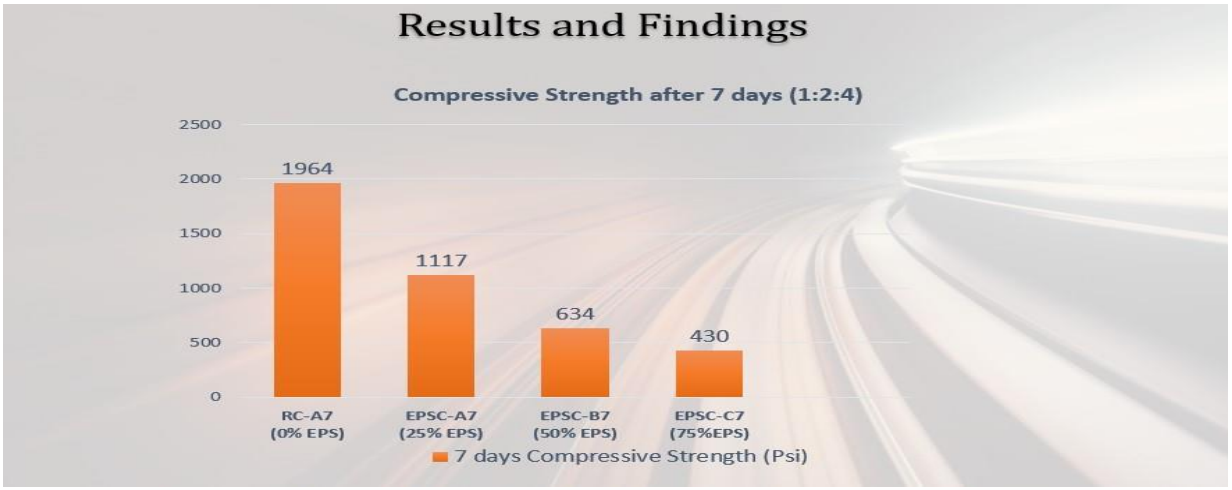


Table: 4.11.4 Sample Data Collection and Result in 7 Days (1:2:4).

4.11.5 Table

Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
RC-A21	1:2:4	100%	0.46	102.07	4.02	206	8.11	4121	4162	21	155	12.68	2747.31	2779.96
				102.06	4.02	205	8.07	4116		21	148	12.68	2623.76	
				102.83	4.05	207	8.15	4249		21	170	12.87	2968.81	
EPSC-A21	1:2:4	25% : 75%	0.46	103.00	4.06	205	8.07	3565	3562	21	95	12.92	1653.57	1583.55
				102.03	4.02	205	8.07	3515		21	87	12.67	1543.25	
				103.42	4.07	206	8.11	3605		21	90	13.02	1553.84	
EPSC-B21	1:2:4	50% : 50%	0.46	102.98	4.05	206	8.11	3002	2950	21	55	12.91	957.70	915.06
				103.34	4.07	205	8.07	2907		21	52	13.00	899.16	
				101.95	4.01	206	8.11	2940		21	50	12.65	888.32	
EPSC-C21	1:2:4	75% : 25%	0.46	102.85	4.05	205	8.07	2378	2331	21	33	12.88	576.07	526.03
				101.55	4.00	206	8.11	2260		21	27	12.55	483.48	
				103.36	4.07	206	8.11	2356		21	30	13.01	518.55	

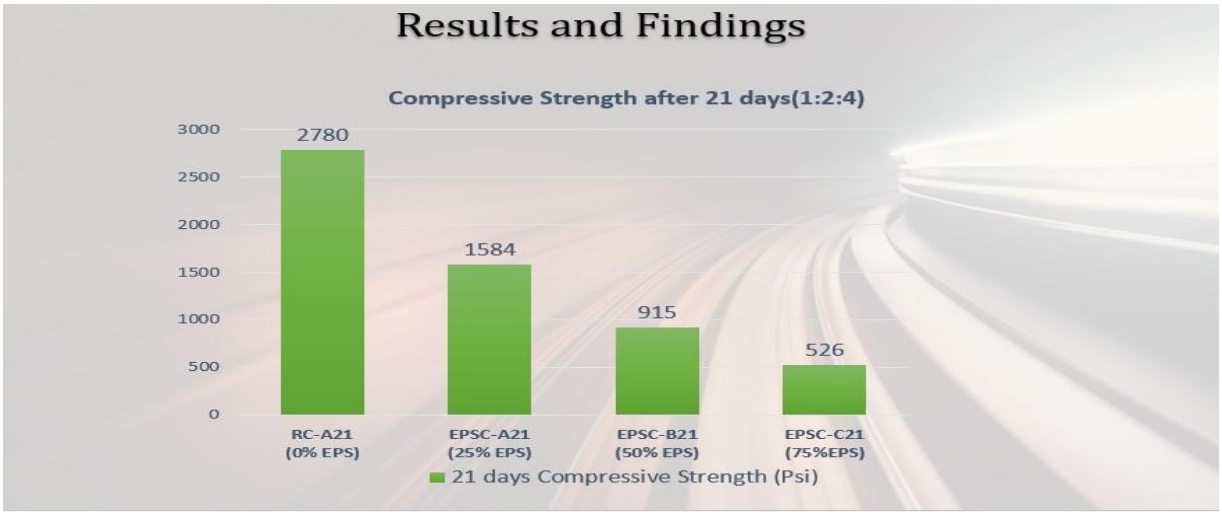


Table: 4.11.5 Sample Data Collection and Result in 21 Days (1:2:4).

4.11.6 Table

Grade Name	Nominal mix	Coarse Aggregate & EPS Beade	W/C Ratio	DIA of Cylinder (mm)	DIA of Cylinder (In)	Height (mm)	Height (In)	Weight (gm)	Average Weight (gm)	Age of Cylinder Day's	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strengthPSI= Load(KN) x 224.8/area (lb.)	Average compressive strength (psi)
RC-A28	1:2:4	100%	0.46	101.70	4.00	199	7.83	3964	4092	**28**	170	12.59	3035.15	2961.90
				102.60	4.04	205	8.07	4194		**28**	172	12.81	3017.22	
				103.70	4.08	203	7.99	4118		**28**	165	13.09	2833.34	
EPSC-A28	1:2:4	25% : 75%	0.46	102.20	4.02	208	8.19	3592	3582	**28**	110	12.72	1944.75	1911.60
				103.20	4.06	206	8.11	3529		**28**	115	12.97	1993.94	
				103.90	4.09	204	8.03	3625		**28**	105	13.14	1796.10	
EPSC-B28	1:2:4	50% : 50%	0.46	101.70	4.00	205	8.07	2976	2981	**28**	65	12.59	1160.50	1155.26
				103.80	4.09	205	8.07	2962		**28**	63	13.12	1079.74	
				102.70	4.04	208	8.19	3004		**28**	70	12.84	1225.55	
EPSC-C28	1:2:4	75% : 25%	0.46	101.70	4.00	202	7.95	2257	2276	**28**	35	12.59	624.88	631.88
				101.90	4.01	205	8.07	2248		**28**	32	12.64	569.08	
				102.60	4.04	205	8.07	2322		**28**	40	12.81	701.68	

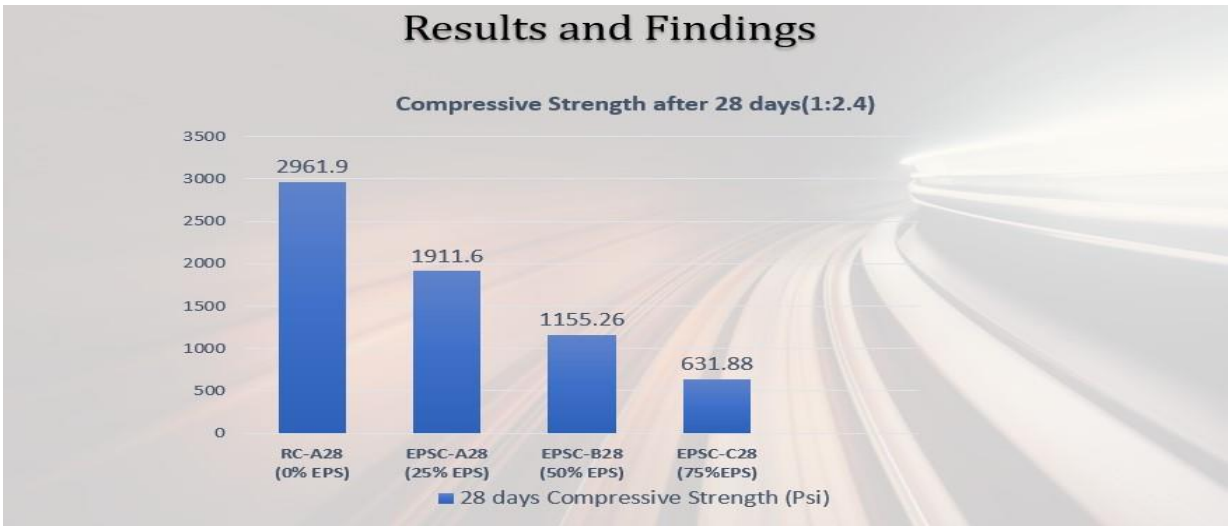


Table: 4.11.6 Sample Data Collection and Result in 28 Days (1:2:4).

CHAPTER 5

CONCLUSIONS AND FUTURE WORKS

5.1 Conclusion:

This data highlights the **compressive strength** of concrete at different curing ages (7, 21, and 28 days) for two common mix ratios: **1:1.5:3** and **1:2:4**. The results show the impact of varying percentages of **EPSC (Expanded Polystyrene Concrete)** on the strength.

(i) Optimal Mixing Techniques:

The experimental results underscore the significance of employing meticulous mixing methodologies, especially when dealing with materials characterized by compressibility, such as expanded polystyrene (EPS). Despite the precise measurement of Polystyrene and mortar quantities to yield one cubic meter, it was observed that the resultant total volume fell short of the anticipated metric. Hence, it is imperative to refine mixing protocols to ensure the attainment of desired volumetric outcomes.

i. Mixed Ratio (1:1.5:3)-7D
- 25% EPSC Average Compressive Strength 1524.81 psi
- 50% EPSC Average Compressive Strength 869.71psi
- 75% EPSC Average Compressive Strength 594.24psi

ii. Mixed Ratio (1:1.5:3) -21D
- 25% EPSC Average Compressive Strength 2102.16 psi
- 50% EPSC Average Compressive Strength 1171.46 psi
- 75% EPSC Average Compressive Strength 813.81 psi

iii. Mixed Ratio (1:1.5:3)-28D
- 25% EPSC Average Compressive Strength 2248.57 psi
- 50% EPSC Average Compressive Strength 1490.04 psi
- 75% EPSC Average Compressive Strength 862.5 psi

i. Mixed Ratio (1:2:4)-7D
- 25% EPSC Average Compressive Strength 1117.42 psi
- 50% EPSC Average Compressive Strength 634.10psi
- 75% EPSC Average Compressive Strength 429.03 psi

ii. Mixed Ratio (1:2:4)-21D
- 25% EPSC Average Compressive Strength 1583.55 psi
- 50% EPSC Average Compressive Strength 915.06 psi
- 75% EPSC Average Compressive Strength 526.03 psi

iii. Mixed Ratio (1:2:4)-28D
- 25% EPSC Average Compressive Strength 1911.60 psi
- 50% EPSC Average Compressive Strength 1155.26 psi

75%EPSC Average Compressive Strength 631.88 psi

5.2 Limitations:

The study primarily focuses on compressive strength; however, other mechanical properties such as tensile strength, flexural strength, and modulus of elasticity could provide a more comprehensive understanding of PS concrete's performance. Here are ten limitations you might consider for your thesis titled "Comparative Analysis of Compressive Strength in Utilizing Polystyrene Bubbles as Partial Fine Aggregate":

A. Material Availability : Limited availability of polystyrene bubbles may restrict the scale and scope of the study, potentially impacting the generalizability of the findings.

B. Geographical Variability: The properties of polystyrene bubbles may vary across different geographical locations due to variations in manufacturing processes or environmental factors, affecting the consistency of results.

C. Particle Size Uniformity : Variations in particle size within the polystyrene bubbles could introduce inconsistencies in the experimental outcomes, influencing the compressive strength results.

D. Mix Design Sensitivity : The effectiveness of polystyrene bubbles as a partial fine aggregate might be sensitive to specific mix designs, and variations in mix proportions could yield different compressive strength outcomes.

E. Testing Conditions : Variations in testing conditions, such as curing temperature, humidity, and duration, could affect the compressive strength results, making it challenging to isolate the impact of polystyrene bubbles accurately.

F. Long-Term Durability : The study may not address the long-term durability implications of using polystyrene bubbles, including factors like shrinkage, creep, and resistance to environmental degradation.

G. Structural Applications: The applicability of findings might be limited to specific structural applications, and extrapolating the results to other construction scenarios may require further validation.

H. Cost Considerations: The economic feasibility of using polystyrene bubbles as a partial fine aggregate, including material costs, transportation, and potential modifications to construction practices, might not be fully explored within the scope of the study.

I. Environmental Impact: While polystyrene bubbles offer potential benefits in reducing the demand for natural aggregates, the environmental impact of their production, disposal, and long-term presence in concrete structures warrants further investigation.

J. Industry Acceptance : The adoption of polystyrene bubbles in construction practices may face resistance or skepticism from industry stakeholders due to concerns regarding performance, regulatory compliance, and established norms, which could influence the practical implementation of research findings.

5.3 Recommendations for Future Works:

Here are 10 recommendations for future works based on our thesis on the comparative analysis of compressive strength in utilizing polystyrene bubbles as partial fine aggregate:

- Investigate the long-term durability of concrete incorporating polystyrene bubbles by subjecting specimens to accelerated weathering conditions mimicking real-world exposure to UV radiation, temperature fluctuations, and moisture.

- Explore the feasibility of utilizing recycled polystyrene materials from various sources, such as packaging and construction waste, to assess their effect on the compressive strength and sustainability of concrete mixtures.

- Conduct studies to optimize the proportion of polystyrene bubbles in concrete mixtures to achieve the desired balance between compressive strength, density reduction, and thermal insulation properties.

- Evaluate the fire resistance of polystyrene-based concrete by conducting standardized fire tests to determine its performance under high-temperature conditions and its potential contribution to fire spread and smoke generation.

- Investigate the environmental impact of using polystyrene bubbles as partial fine aggregate in concrete mixtures, including their carbon footprint, energy consumption, and potential for reducing overall material usage and waste generation.

- Assess the mechanical properties, such as tensile strength and modulus of elasticity, of concrete containing polystyrene bubbles to understand its behavior under different loading conditions and its suitability for structural applications.

- Investigate the compatibility of polystyrene-modified concrete with various types of admixtures, including superplasticizers and air-entraining agents, to optimize workability, hydration kinetics, and overall performance.

- Explore innovative construction techniques and applications for polystyrene-based concrete, such as 3D printing, prefabrication, and lightweight structural elements, to capitalize on its unique properties and expand its range of potential uses.

- Conduct life cycle assessments (LCAs) to compare the environmental and economic performance of polystyrene-modified concrete with conventional concrete mixtures, taking into account factors such as raw material extraction, production, transportation, use, and end-of-life disposal.

- Collaborate with industry stakeholders, regulatory agencies, and standardization bodies to develop guidelines, specifications, and best practices for the responsible use of polystyrene- based concrete in construction projects, ensuring compliance with safety, performance, and sustainability requirements.

5.4 Scope for Future Study:

Scope for Future Study in Comparative Analysis of Compressive Strength in Utilizing Polystyrene Bubbles as Partial Fine Aggregate-

As research on the application of polystyrene bubbles as a partial fine aggregate continues to evolve, several avenues emerge for future exploration and enhancement. This scope for future study not only extends the breadth of knowledge within this field but also offers practical implications for sustainable construction practices. Herein lie some promising directions:

- As the construction industry continues to evolve, the quest for sustainable and innovative materials becomes imperative. One such material that has gained attention is polystyrene bubbles, often utilized as a partial fine aggregate in concrete mixes. This thesis delves into the comparative analysis of compressive strength concerning the incorporation of polystyrene bubbles, shedding light on its potential and paving the way for future studies.

- The utilization of polystyrene bubbles offers several advantages, including reduced density, improved thermal insulation, and enhanced workability of concrete mixes. Its impact on compressive strength remains a topic of debate and exploration. Through a meticulous comparative analysis, this study seeks to elucidate the intricate relationship between the incorporation of polystyrene bubbles and the compressive strength of concrete.

- One avenue for future study lies in investigating the optimal percentage of polystyrene bubbles to be incorporated into concrete mixes. While past research has explored varying proportions, there remains scope for a more comprehensive examination to ascertain the ideal balance between density reduction and compressive strength enhancement. Studying the long-term effects of polystyrene bubble inclusion on the durability and structural integrity of concrete will provide valuable insights for real-world applications.

- The influence of different curing conditions on the compressive strength of polystyrene bubble- infused concrete warrants further exploration. By subjecting specimens to diverse curing regimes, such as temperature variations and moisture exposure, researchers can gain a deeper understanding of how environmental factors interact with the material properties, thus optimizing performance in different climates and conditions.

- Delving into the potential synergies between polystyrene bubbles and supplementary cementitious materials (SCMs) presents an exciting avenue for future investigation. SCMs like fly ash and silica fume have been extensively studied for their ability to enhance concrete properties. Exploring how the combination of polystyrene bubbles and SCMs influences compressive strength can unlock new possibilities for sustainable construction practices.

By pursuing these avenues for future study, researchers can further enhance the understanding and practical applications of polystyrene bubble-modified concrete, paving the way for more sustainable and resilient construction practices.

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