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Sonargaon University (SU)
সোনারগাঁও ইউনিভার্সিটি (এসইউ)

THESIS TITLE: COMPARATIVE ANALYSIS OF COMPRESSIVE STRENGTH OF CONCRETE BY UTILIZING POLYSTYRENE BUBBLES AS PARTIAL REPLACEMENT OF FINE AGGREGATE.

Project & Thesis
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Comparative Analysis Of Compressive Strength Of Concrete By Utilizing Polystyrene Bubbles As Partial Replacement Of Fine Aggregate.

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Section 21B Semester

Year - Spring 2024

BOARD OF EXAMINERS

The thesis titled **" Comparative Analysis Of Compressive Strength Of Concrete By Utilizing Polystyrene Bubbles As Partial Replacement Of Fine Aggregate."** Submitted by Md. Asaduzzaman (ID: CE2003021042), Md. Badol Hossain (ID: CE2003021049), Md. Asaduzzaman (CE2003021071) & Abdul Alim Howlader (ID: CE2102023035). 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. Their research on "Comparative Analysis of Compressive Strength in the Use of Polystyrene Bubbles" 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 21B, Semester Year 2024, at Sonargaon University, hereby declare that our thesis titled " **Comparative Analysis of Compressive Strength of Concrete by Utilizing Polystyrene Bubbles as Partial Replacement of Fine Aggregate** " is our original work. We affirm the authenticity of the data, analysis, and conclusions presented in this thesis. This research has not been submitted for any academic purpose prior to this declaration. We extend our sincere gratitude to our advisors, professors, and all other sources that provided valuable insights and guidance throughout the research process. Their support was instrumental in the completion of this project. We extend our sincere gratitude to all sources and references that contributed to our research. This work represents our honest and diligent efforts towards advancing knowledge in this field.

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in partial fulfillment of the requirements for the Award of the degree of B. Sc in Civil Engineering at Sonargaon University, 147/ Green Road , Dhaka-1215, Bangladesh, is a record of the student's own work conducted during the period September 2023 to April 2014 under my supervision and guidance.

To the best of my knowledge, this thesis has not been submitted in part or full elsewhere in any other University or Institution for the award of any degree. It is further understood that by this certificate, the undersigned do not endorse or approve any statement made, opinion expressed, or conclusion drawn therein but approve the thesis only for the purpose for which it is submitted.

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Dedicated

To

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.

ACKNOWLEDGEMENTS

We express our gratitude to Allah for guiding us through the completion of this thesis. Our heartfelt appreciation goes to the university authorities for granting us the opportunity to undertake the research outlined in this paper.

Foremost, we owe a debt of gratitude to our thesis supervisor, Kamrun Nahar Mim, Lecturer at the Department of Civil Engineering, Sonargaon University of Bangladesh (SU). Her unwavering support, continuous guidance, constructive criticism, affectionate encouragement, patient listening, and ample time for discussion and invaluable suggestions at every stage of this project were instrumental in its fruition. Her keen interest in our topic and insightful advice served as a constant source of inspiration throughout. Furthermore, we extend our heartfelt thanks to all the faculty members and staff of the Department of Civil Engineering at SU for their unwavering support and cooperation throughout this endeavor. Their collective efforts have enriched our academic journey and contributed significantly to the successful completion of this thesis.

we acknowledge with deep appreciation the support and guidance provided by all those who have contributed to this endeavor, directly or indirectly. Their assistance has been invaluable in shaping our research and enhancing our academic growth.

Thank you.

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ABSTRACT

This study presents a comparative analysis of compressive strength in concrete utilizing polystyrene bubbles as both coarse and fine aggregates. The mechanical and durability properties of concrete incorporating polystyrene bubbles as partial replacements for natural fine 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 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 CO_2 emissions, the future of concrete holds boundless possibilities for shaping a more sustainable built environment. ["Properties of Concrete." Fifth Edition, Pearson, 2011.]

1.1.1 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.

[ASTM C330 / C330M - Standard Specification for Lightweight Aggregates for Structural Concrete].

1.2 Concrete Making Materials:

1.2.1 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.

["Design and Control of Concrete Mixtures" by Steven H. Kosmatka, Beatrix Kerkhoff, and William C. Panarese"].

Fig: 1.2.1.1 Cement.

1.2.2 Aggregate:

Aggregates play a pivotal role in the world of concrete, comprising a substantial portion of its volume and exerting a significant influence on its properties. Derived primarily from natural rock sources such as crushed stone, gravels, and sands, aggregates are indispensable constituents that contribute to the structural integrity, durability, and overall performance of concrete structures. In addition to natural sources, synthetic materials like slag and expanded clay or shale are also utilized, particularly in lightweight concretes, further diversifying the aggregate landscape. Classification of aggregates serves multiple purposes, facilitating easier identification and aiding in understanding their diverse characteristics. Various parameters, including source, specific gravity, particle size, shape, surface texture, and mineral composition, are considered in classification. Typically categorized as natural or artificial, aggregates are further distinguished based on specific gravity into normal weight, lightweight, and heavyweight aggregates, each possessing unique properties that impact concrete behavior. The incorporation of aggregates into concrete offers several advantages over using cement paste alone. Economically, aggregates are a cost-effective filler, extending the mix and reducing overall material expenses. Aggregates mitigate shrinkage and creep, enhancing volume stability and minimizing structural deformations over time. Additionally, aggregates contribute to the durability of concrete, providing resistance against deterioration processes that predominantly affect cement paste. The gradation of aggregate within concrete mixes significantly influences workability and strength. Optimal gradation ensures proper cohesion and bond between aggregate and cement paste, promoting the formation of robust concrete structures. The shape and texture of aggregates influence water demand and the integrity of the aggregate-cement paste interface, highlighting the importance of selecting suitable aggregate types for specific applications. In summary, aggregates are indispensable components of concrete, essential for achieving economic efficiency, structural stability, and long-term durability. Their diverse properties and classifications offer engineers and builders a wide array of options to tailor concrete mixes to specific project requirements, ensuring the successful realization of robust and resilient structures in the built environment.

Aggregates are classified as natural or artificial aggregates according to their source with regard to their specific gravity or unit weight, concrete aggregates are classified as:-

(i) Normal Weight Aggregates **:** Normal weight aggregates have specific gravities of between 2.4 and 2.8.

(ii) Lightweight Aggregates **:** Aggregates with a specific gravity of less than Aggregates with a specific gravity of less than 2.4 are called lightweight aggregates.

(iii) Heavyweight Aggregates **:** Aggregates with a specific gravity more than 2.8 are called heavyweight aggregates.

["Properties of Concrete" by A.M. Neville”].

Fig: 1.2.2.1 Aggregate.

1.2.3 Water:

Water, an essential component in concrete making, plays a pivotal role in determining the strength, workability, and durability of the final product. In the realm of concrete materials, water acts as a binder, facilitating the hydration process of cement particles and ensuring proper adhesion between aggregates. Its significance extends beyond mere hydration, influencing various properties crucial for constructing robust structures. Firstly, the water-to-cement ratio (w/c) stands as a critical factor in concrete mix design. The ratio directly impacts the strength and durability of concrete. An optimal w/c ratio ensures sufficient hydration of cement particles without excess water that may lead to weakened bonds and increased porosity. Conversely, insufficient water content can result in incomplete hydration, compromising the concrete's strength and workability. Thus, achieving the right balance is imperative for optimal performance. Without adequate water content, the concrete may become too stiff, making it challenging to work with and increasing the likelihood of voids or honeycombs. Conversely, excessive water can lead to segregation, where the aggregates settle, and the cement-water paste rises, causing uneven distribution of materials and compromising structural integrity. Water plays a crucial role in the curing process of concrete. Adequate moisture is essential to maintain hydration and strengthen the concrete matrix. Proper curing prevents cracking, enhances surface durability, and improves resistance to external factors such as weathering and chemical attacks. Techniques such as wet curing, membrane curing, and curing compounds are employed to regulate moisture levels and promote optimal hydration, ensuring the longevity of concrete structures. While water is indispensable in concrete production, its quality can significantly impact the properties of the final product. Contaminants such as dissolved salts, organic matter, and impurities can adversely affect the setting time, strength development, and overall performance of concrete.

Therefore, utilizing clean, potable water or treating water from alternative sources is essential to mitigate potential detrimental effects. Water is a fundamental component in concrete making, influencing its strength, workability, and durability. Achieving the right balance of water content is crucial to ensure optimal performance and longevity of concrete structures. By understanding the intricate role of water and implementing appropriate measures, engineers and constructors can produce high-quality concrete that meets the demands of diverse construction projects.

[Neville, A. M. (1996). Properties of Concrete (4th ed.). Pearson.]

Fig: 1.2.3.1 Water.

1.2.4 Lightweight 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 aggregates traps air within the concrete, creating a barrier against heat transfer. This thermal insulation capability helps regulate indoor temperatures, 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.

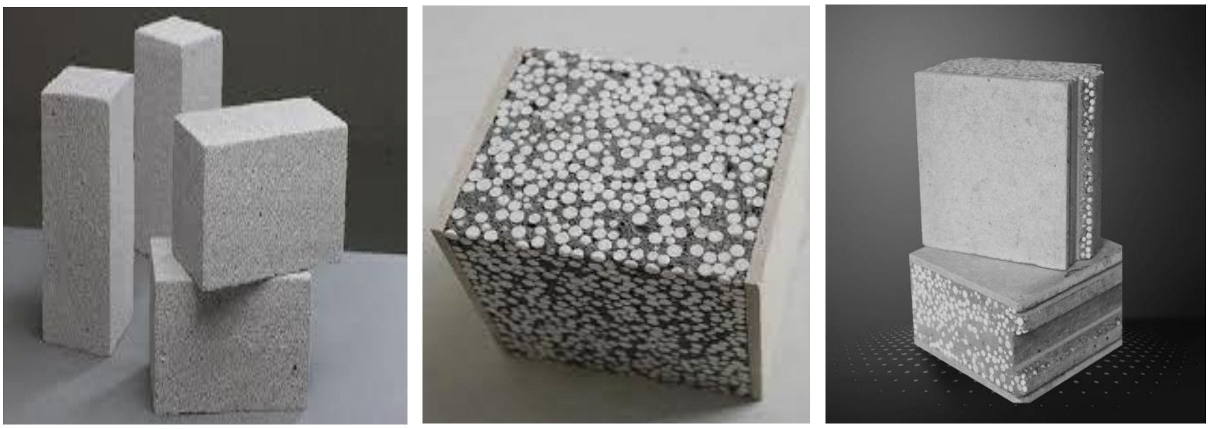

Fig: 1.2.4.1 Lightweight Concrete.

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.

["Lightweight Aggregate Concrete: Science, Technology, and Applications" by Satish Chandra and Leif Berntsson.]

1.2.5 Expanded polystyrene Beads (EPS):

Expanded polystyrene (EPS) is a lightweight cellular plastics material consisting of fine spherical shaped particles which are comprised of about 98% air and 2% polystyrene. Therefore, it has a good sound and thermal insulation characteristics as well as impact resistance. Expanded polystyrene (EPS) beads find versatile applications due to their unique properties. Comprising primarily of air and a small fraction of polystyrene, EPS exhibits exceptional qualities ideal for various uses. Its closed-cell structure renders it impermeable to water, making it an excellent choice for insulation against both sound and temperature fluctuations. Moreover, EPS boasts remarkable resilience against impacts, ensuring durability in diverse conditions. Being inert, EPS showcases resistance to numerous chemicals, including alkalis, acids, and oxidizing agents. However, prolonged exposure to certain substances like paraffin oil and vegetable oils can compromise its integrity over time. Nevertheless, its broad spectrum of applications encompasses packaging, construction, and crafts, among others. EPS's lightweight nature and insulating properties make it indispensable across industries where protection, buoyancy, and thermal regulation are paramount.

1.2.6 Expanded Polystyrene Concrete:

Expanded Polystyrene Concrete (EPS concrete) represents a remarkable innovation in construction materials. This lightweight aggregate concrete utilizes synthetic expanded polystyrene beads to reduce density, offering a host of benefits. By partially or fully replacing traditional aggregates, EPS concrete achieves a significant reduction in weight without compromising structural integrity. Its manufacturing process is relatively straightforward, leveraging readily available raw materials. This type of concrete is renowned for its exceptional thermal and acoustic properties, making it an attractive choice for various applications. Whether used in residential, commercial, or industrial projects, EPS concrete stands out for its efficiency and effectiveness. Its lightweight nature facilitates easier handling and transportation, while its insulation properties contribute to energy efficiency and comfort in built environments. As sustainable construction practices gain traction, EPS concrete emerges as a viable solution, offering durability, versatility, and environmental responsibility.

1.3 Application of Expanded Polystyrene Concrete:

The versatility of Expanded Polystyrene (EPS) lightweight concrete opens up a multitude of applications, leveraging its unique properties in various fields:

(i). Cold Store Construction : EPS concrete is often used in conjunction with other materials like steel to create sandwich panels, particularly valuable in cold store construction due to its excellent thermal insulation properties.

(ii). Impact Resistance : With its remarkable energy absorption capabilities, polystyrene concrete serves as an effective protective layer for structures requiring impact resistance. This is particularly beneficial for safeguarding buried military installations and fenders in offshore oil platforms.

(iii). Prefabricated Components : EPS concrete finds extensive use in the creation of prefabricated non-load bearing panels, hollow and solid blocks, as well as lightweight sandwich panels, facilitating rapid construction processes.

(iv). Highway Construction : In highway construction, EPS concrete plays a vital role in sub-base applications, especially in regions prone to frost, where its use enhances subgrade stability.

(v). Building and Construction : The adaptability of EPS concrete makes it suitable for a wide array of applications in building and construction. It excels where a combination of insulation and strength is required, such as in roofs, cladding panels, curtain walls, and ceilings.

(vi). Structural Elements : Expanded polystyrene concrete proves valuable in the creation of load-bearing concrete blocks, floating marine structures, and sub-floor systems, offering durability and reliability in demanding environments.

(vii). Insulation in Australia : In Australia, EPS aggregate concrete finds primary application in manufacturing non-structural components of concrete buildings. These include perimeter insulation, roof insulation, and masonry insulation, contributing to energy efficiency and comfort in buildings.

Expanded Polystyrene Concrete stands as a versatile material, offering solutions across diverse industries, from enhancing structural integrity to improving energy efficiency and safety. Its wide-ranging applications underscore its importance in modern construction practices.

1.4 Objective of the Study:

The primary objective of this study is to conduct a comparative analysis of the compressive strength of concrete when polystyrene bubbles are used as a partial replacement for fine aggregate. Traditional concrete relies heavily on natural sand as a fine aggregate, but with increasing environmental concerns and the depletion of natural resources, there is a pressing need to explore alternative materials. Polystyrene, a non-biodegradable material commonly found in waste, presents a potential sustainable alternative. This research aims to investigate the feasibility and performance implications of incorporating polystyrene bubbles into concrete mixes.

Specifically, the study seeks to achieve the following objectives:

(i) **Evaluate the Compressive Strength:** Determine how the inclusion of polystyrene bubbles at various replacement levels affects the compressive strength of concrete. This will involve preparing concrete samples with different percentages of polystyrene bubbles substituting fine aggregate and testing their compressive strength at specific curing intervals.

(ii) **Optimize Replacement Levels:** Identify the optimal percentage of polystyrene bubbles that can be used to replace fine aggregate without significantly compromising the structural integrity of the concrete. This involves a detailed analysis of the mechanical properties of concrete at varying replacement levels.

(iii) **Compare with Conventional Concrete:** Establish a comparative framework between traditional concrete and polystyrene-modified concrete in terms of compressive strength. This comparison will help determine the viability of using polystyrene as an alternative material.

(iv) **Assess Workability and Durability:** Besides compressive strength, the study will also assess the workability and durability of the concrete mixes. This includes evaluating how the addition of polystyrene bubbles affects the concrete's consistency, ease of handling, and resistance to environmental factors.

(v) **Environmental and Economic Impact Analysis:** Analyze the environmental benefits and economic implications of using polystyrene in concrete. This objective aims to highlight the potential reduction in environmental footprint and cost savings associated with waste polystyrene utilization.

By addressing these objectives, the study aims to contribute to the development of more sustainable construction materials, providing insights that could lead to reduced reliance on natural resources and enhanced waste management practices. The findings could pave the way for innovative concrete mix designs that align with sustainability goals while maintaining the necessary structural performance.

1.5 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, Ravindrarajah 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/m^3, 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, Ravindrarajah 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 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.

3.2 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 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.

3.2.1 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.

3.2.2 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 guarantees 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.

Fig: 3.2.2.1 Sample sand.

Table 3.2.2.1: Sieve Analysis of Fine Aggregate

Sieve size	Weight Retained	Cumulative weight retained (gm)	Cumulative % weight retained	Passing
4.75	66	66	6.60	93.40
2.36	130	196	19.60	80.40
1.18	240	436	43.60	54.40
600µ	110	546	54.60	44.40
300 µ	244	790	79.00	20.00
150 µ	110	900	90.00	9.00
75 µ	72	972		
	972		ΣF=293.40	

Fineness modulus of fine Aggregate = (ΣF/100)

= (293.40/100)

= 2.93

3.2.3 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.

Fig: 3.2.3.1 Sample Coarse Aggregate.

Table 3.2.4.1: Sieve Analysis of Coarse Aggregate (12mm)

Sieve size	Weight Retained (gm)	Cumulative weight retained (gm)	%Cumulative weight retained	Passing
40	0.00	0.00	0.00	100.00
20	93.00	93.00	3.10	96.90
16	183.00	276.00	9.20	90.80
12.5	267.00	543.00	18.10	81.90
10	2058.00	2601.00	86.70	13.30
4.75	399.00	3000	100.00	0.00
Sum	3000		ΣC=217.10	

Fineness modulus of fine Aggregate = (ΣC+500)/100
= {(217.10+500)/100}
= 7.10

3.2.4 Sample Polystyrene:

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 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.

Fig: 3.2.4.1 Sample Polystyrene.

3.3 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 applications.

Fig: 3.3.1 Weight measurement of Polystyrene.

3.4 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 lighter 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.

Fig: 3.4.1 Mortar mixing.

3.5 Sample making:

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.

Fig: 3.5.1 Sample making.

3.6 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.

Fig: 3.6.1 Curing of Sample.

3.7 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.

Fig: 3.7.1 Sample.

CHAPTER 4
TESTING , 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 : **Comparison on compressive strength of concrete by using polystyrene bubbles as fine aggregate.**

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

Grade Name	Nominal mix	Fine agregate Ratio.Polystyrene & Sand	W/C Ratio	Compressive strength (28days) (psi)	Average compressive strength (psi)	Weight of Cylinder	Average Unit Weight
Grade A	1:4:8	10% & 90%	0.45	741 779 719	746	3349 3702 3672	3574
Grade B	1:4:8	20% & 80%	0.45	515 578 558	550	3537 3474 3538	3516
Grade C	1:4:8	30% & 70%	0.45	425 497	461	3584 3474	3529
Grade D	1:4:8	40% & 60%	0.45	419 365 407	397	3396 3127 3360	3294
Grade E	1:3:6	10% & 90%	0.45	1429 1459 1480	1456	3352 3432 3499	3428
Grade F	1:3:6	20% & 80%	0.45	1246 1208 1158	1204	3323 3306 3348	3326
Grade G	1:3:6	30% & 70%	0.45	979 969 959	969	3328 3220 3350	3299
Grade H	1:3:6	40% & 60%	0.45	719 785 840	782	3033 3171 3161	3122
Grade I	1:2:4	10% & 90%	0.45	2189 2105 2254	2183	3422 3434 3428	3428
Grade J	1:2:4	20% & 80%	0.45	1761 1909 1797	1822	3312 3334 3368	3338
Grade K	1:2:4	30% & 70%	0.45	1445 1360 1526	1444	3265 3228 3396	3296
Grade L	1:2:4	40% & 60%	0.45	910 1134 983	1009	3143 3207 3151	3167
Grade M	1:1.5:3	10% & 90%	0.45	2942 2746 2820	2836	3409 3439 3415	3421
Grade N	1:1.5:3	20% & 80%	0.45	2504 2412 2422	2446	3333 3407 3382	3374
Grade O	1:1.5:3	30% & 70%	0.45	2015 1954 2014	1994	3285 3312 3330	3309
Grade P	1:1.5:3	40% & 60%	0.45	1432 1466 1567	1488	3037 3092 3038	3056

Table: 4.2.1 Testing Plan.

4.3 Testing:

4.3.1 Testing the Course Aggregate & Weight measurement of CA:

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 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.

Fig 4.3.1.1: Weight measurement of CA.

Fineness modulus of Coarse Aggregate $= (\Sigma C+500)/100$

$= \{(217.10+500)/100\}$

$= 7.10$

Fineness modulus of fine Aggregate $= (\Sigma F/100)$

$= (293.40/100)$

$= 2.93$

4.4 sample 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.

Fig: 4.4.1 Taking weight measurements and size measurements.

Fig: 4.7.2 Size measurements of Sample.

4.5 Size measurements of Sample:

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.

Fig: 4.5.1 Size & measurements of Sample.

4.6 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.

Fig: 4.6.1 Testing compressive strength.

4.7 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.

Fig: 4.7.1 Testing compressive strength.

4.8 Results:

4.8.1 Table:

Thesis Title: Comparative Analysis Of Compressive Strength In Utilizing Polystyrene Bubbles As Partial Fine Aggregate.

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

Sl No.	Sample	Nominal Mix	Fine aggregate Ratio. Polystyrene & Sand	W/C Ratio	Dia (mm)	Dia (In)	Height (mm)	Weight (Gm)	Average Weight (gm)	Weight of concrete kg/CuM	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strength PSI= Load(KN) x 224.8/Area (lb)	Average compressive strength psi
1	Sample A	1:4:8	10% & 90%	0.45	102.21	4.027	206	3349	3574	2096.94	42	12.74	741	746
2					103.18	4.065	206	3702			45	12.98	779	
3					102.55	4.040	205	3672			41	12.82	719	
4	Sample B	1:4:8	20% & 80%	0.45	101.88	4.014	205.5	3537	3516	2075.01	29	12.65	515	550
5					102.6	4.042	205.5	3474			33	12.83	578	
6					102.81	4.051	205	3538			32	12.89	558	
7	Sample C	1:4:8	30% & 70%	0.45	102.08	4.022	205	3584	3529	2099.43	24	12.70	425	461
8					101.87	4.014	206	3474			28	12.65	497	
9														
10	Sample D	1:4:8	40% & 60%	0.45	102.8	4.050	205	3396	3294	1939.20	24	12.88	419	397
11					103.05	4.060	205	3127			21	12.95	365	
12					102.07	4.022	205	3360			23	12.70	407	

Result for set 1: Sample (A to D).

<u>Chart for first set grade (A to D):</u>

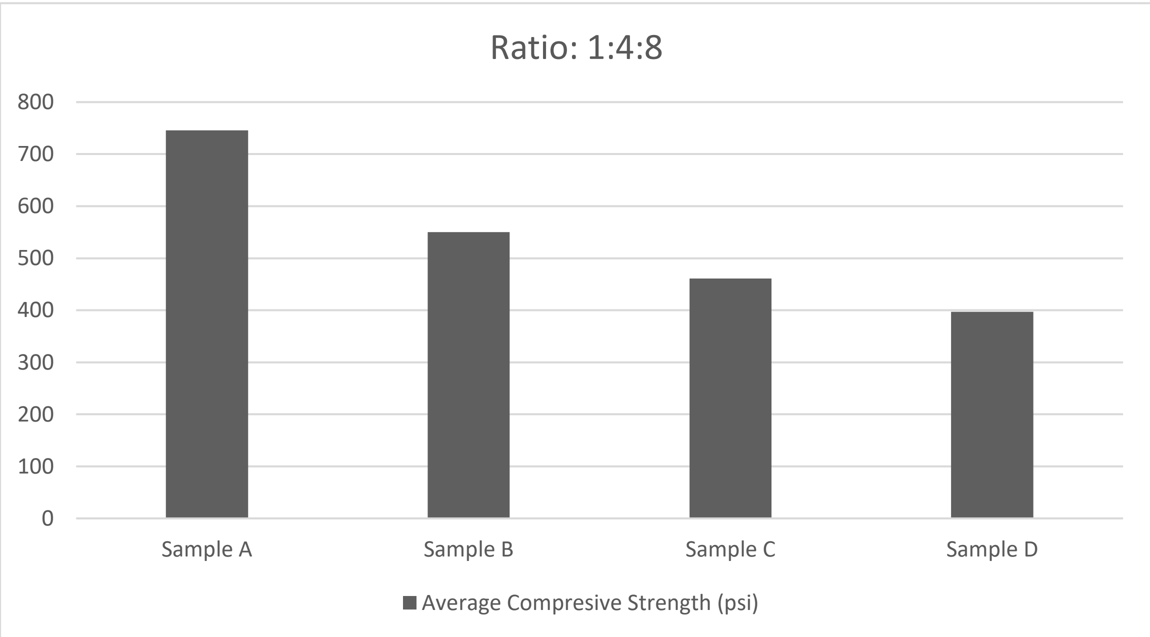

Fig: 4.11.1.1 Chart Graph for Sample Type (A to D).

4.8.2 Table:

Thesis Title: Comparative Analysis Of Compressive Strength In Utilizing Polystyrene Bubbles As Partial Fine Aggregate.

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

Sl No.	Sample	Nominal Mix	Fine aggregate Ratio. Polystyrene & Sand	W/C Ratio	Dia (mm)	Dia (In)	Height (mm)	Weight (Gm)	Average Weight (gm)	Weight of concrete kg/CuM	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strength PSI= Load(KN) x 224.8/Area (lb)	Average compressive strength psi
13	Sample E	1:3:6	10% & 90%	0.45	102.87	4.053	205	3552	3628	2125.17	82	12.90	1429	1456
14					103.02	4.059	204.5	3632			84	12.94	1459	
15					102.9	4.054	205	3699			85	12.91	1480	
16	Sample F	1:3:6	20% & 80%	0.45	102.5	4.039	206	3523	3526	2076.09	71	12.81	1246	1204
17					102.61	4.043	205	3506			69	12.84	1208	
18					102.51	4.039	205	3548			66	12.81	1158	
19	Sample G	1:3:6	30% & 70%	0.45	103.6	4.082	205	3528	3499	2034.89	57	13.09	979	969
20					103.25	4.068	205	3420			56	13.00	969	
21					102.83	4.052	205.5	3550			55	12.89	959	
22	Sample H	1:3:6	40% & 60%	0.45	102.52	4.039	205	3233	3322	1953.35	41	12.81	719	782
23					102.81	4.051	206	3371			45	12.89	785	
24					102.62	4.043	204.5	3361			48	12.84	840	

Result for set 2: Sample (E to H).

Chart for first set grade (E to H):

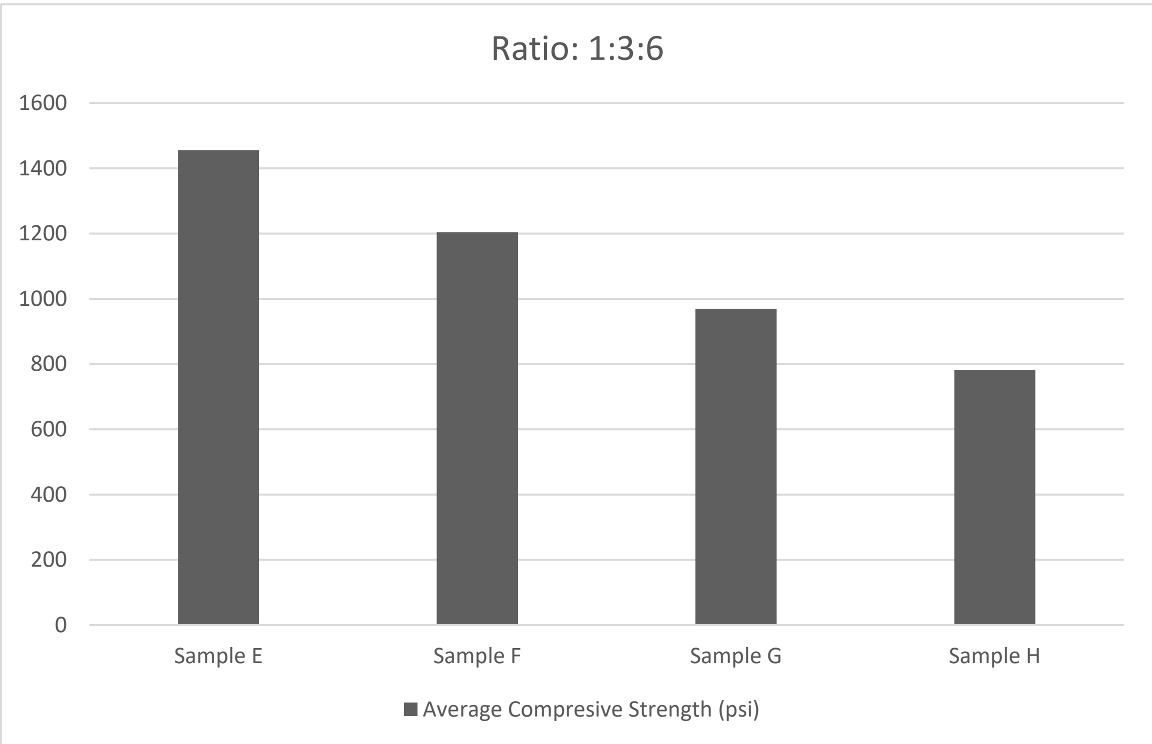

Fig: 4.11.2.1 Chart Graph for Sample Type (E to H).

4.8.3 Table:

Thesis Title: Comparative Analysis Of Compressive Strength In Utilizing Polystyrene Bubbles As Partial Fine Aggregate.

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

Sl No.	Sample	Nominal Mix	Fine aggregate Ratio. Polystyrene & Sand	W/C Ratio	Dia (mm)	Dia (In)	Height (mm)	Weight (Gm)	Average Weight (gm)	Weight of concrete kg/CuM	Load KN	Area= πd²/4 (in²)	Compressive strength PSI= Load(KN) x 224.8/Area (lb)	Average compressive strength psi
25	Sample I	1:2:4	10% & 90%	0.45	102.61	4.043	205	3422	3428	2029.22	125	12.84	2189	2183
26					102.53	4.040	205	3434			120	12.82	2105	
27					101.92	4.016	205	3428			127	12.66	2254	
28	Sample J	1:2:4	20% & 80%	0.45	102.83	4.052	205	3312	3338	1954.89	101	12.89	1761	1822
29					103.07	4.061	205	3334			110	12.95	1909	
30					102.81	4.051	205	3368			103	12.89	1797	
31	Sample K	1:2:4	30% & 70%	0.45	102.91	4.055	205	3265	3296	1934.56	87	12.91	1515	1467
32					102.83	4.052	205.5	3228			78	12.89	1360	
33					102.52	4.039	205	3396			87	12.81	1526	
34	Sample L	1:2:4	40% & 60%	0.45	102.63	4.044	205	3143	3167	1864.04	52	12.84	910	1009
35					102.81	4.051	205	3207			65	12.89	1134	
36					102.5	4.039	205	3151			56	12.81	983	

Result for set 3: Sample (I to L).

Chart for first set grade (I to L):

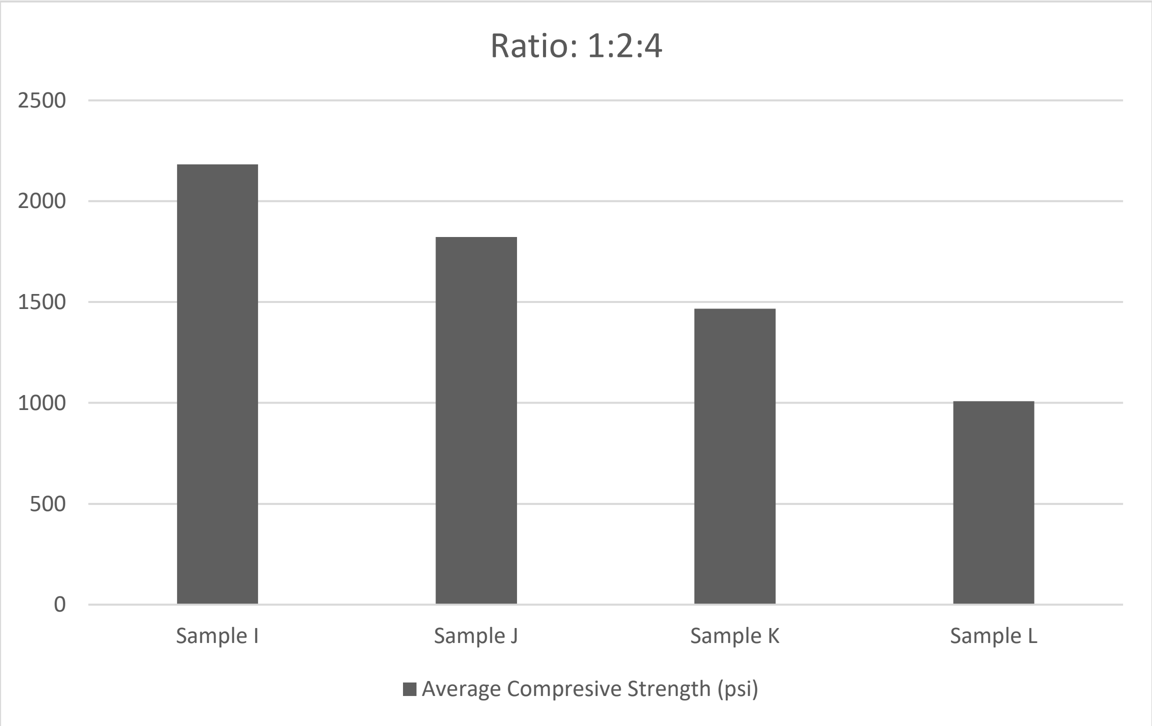

Fig: 4.11.3.1 Chart Graph for Sample Type (I to L).

4.8.4 Table:

Thesis Title: Comparative Analysis Of Compressive Strength In Utilizing Polystyrene Bubbles As Partial Fine Aggregate.

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

Sl No.	Sample	Nominal Mix	Fine aggregate Ratio. Polystyrene & Sand	W/C Ratio	Dia (mm)	Dia (In)	Height (mm)	Weight (Gm)	Average Weight (gm)	Weight of concrete kg/CuM	Load KN	Area= $\pi d^2/4$ (in^2)	Compressive strength PSI= Load(KN) x 224.8/Area (lb)	Average compressive strength psi
37	Sample M	1:1.5:3	10% & 90%	0.45	102.61	4.043	205	3409	3421	2010.27	171	12.84	2995	2912
38					102.67	4.045	205	3439			165	12.85	2886	
39					102.91	4.055	205	3415			164	12.91	2855	
40	Sample N	1:1.5:3	20% & 80%	0.45	102.98	4.057	206	3333	3374	1966.85	144	12.93	2504	2446
41					103.08	4.061	204.5	3407			139	12.95	2412	
42					103.24	4.068	205	3382			140	13.00	2422	
43	Sample O	1:1.5:3	30% & 70%	0.45	102.57	4.041	205	3285	3309	1947.11	115	12.83	2015	1994
44					102.08	4.050	205	3312			112	12.88	1954	
45					102.61	4.043	205	3330			115	12.84	2014	
46	Sample P	1:1.5:3	40% & 60%	0.45	102.75	4.048	205	3037	3022	1792.33	82	12.87	1432	1488
47					102.08	4.050	205	3092			84	12.88	1466	
48					102.92	4.055	205	3038			90	12.91	1567	

Result for set 4: Sample (M to P).

Chart for first set grade (M to P):

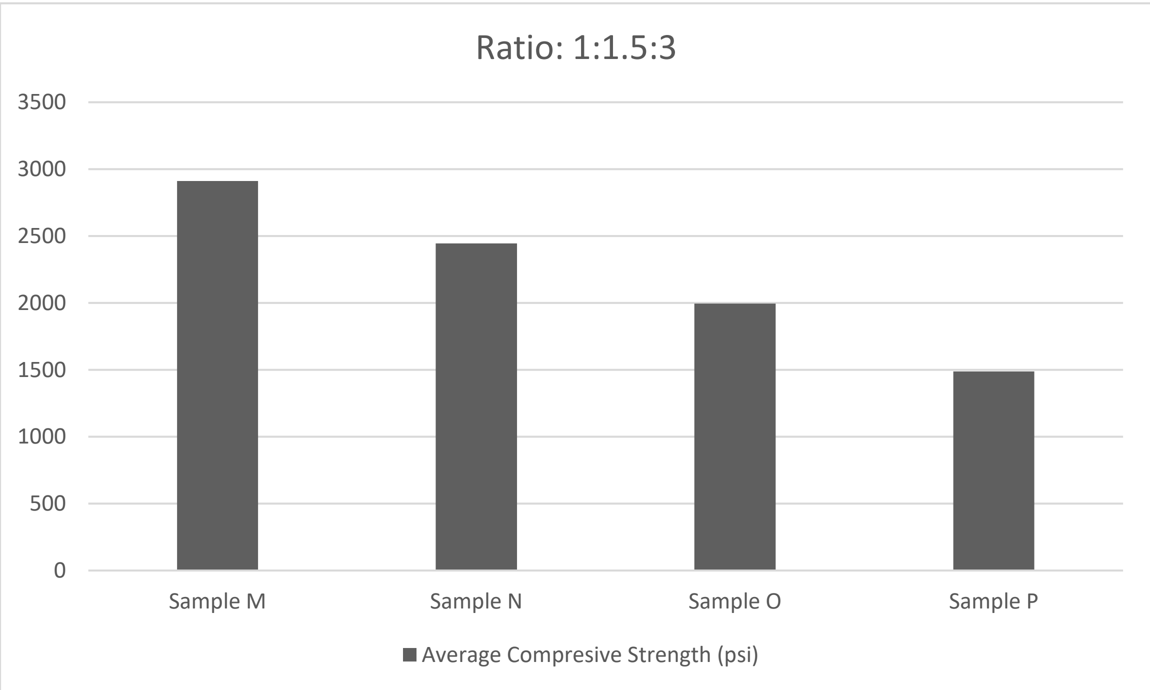

Fig: 4.11.4.1 Chart Graph for Sample Type (A to D).

CHAPTER 5

CONCLUSIONS AND FUTURE WORKS

5.1 Conclusion:

The study titled "Comparative Analysis of Compressive Strength of Concrete by Utilizing Polystyrene Bubbles as Partial Replacement of Fine Aggregate" aimed to explore the feasibility of using polystyrene bubbles as a substitute for fine aggregate in concrete. The research sought to assess the impact of this substitution on the compressive strength of concrete, a critical parameter in determining the material's suitability for construction purposes.

The experimental investigation demonstrated several key findings:

Feasibility of Polystyrene as a Replacement:
The incorporation of polystyrene bubbles in concrete as a partial replacement for fine aggregate was feasible up to a certain percentage. The experimental results showed that polystyrene could be effectively mixed with other concrete components without causing segregation or significant workability issues. This points to the potential of polystyrene as an alternative material in concrete production, promoting the use of waste materials and contributing to environmental sustainability.

Compressive Strength Variations:
The compressive strength of concrete was observed to decrease with the increase in the percentage of polystyrene bubbles. However, at lower replacement levels (up to 10-15%), the reduction in compressive strength was within acceptable limits for certain non-structural applications. This indicates that while polystyrene-modified concrete may not be suitable for high-load-bearing structures, it can still be effectively used in applications where lower compressive strength is permissible.

Density Reduction:
One of the significant advantages of using polystyrene bubbles was the reduction in the density of the concrete. The lightweight nature of polystyrene contributed to a lighter concrete mix, which can be beneficial in reducing the overall dead load of structures. This can be particularly advantageous in applications such as lightweight panels, precast blocks, and other non-structural elements where reduced weight is desirable.

Environmental Impact:
The use of polystyrene, a non-biodegradable material, in concrete helps in mitigating environmental issues associated with its disposal. By integrating polystyrene waste into concrete, the study highlights a sustainable approach to waste management, aligning with global efforts to reduce landfill waste and promote recycling practices.

Economic Considerations:
The partial replacement of fine aggregate with polystyrene bubbles can also result in cost savings. Fine aggregate, such as sand, is a finite resource, and its extraction can have environmental and economic implications. Utilizing polystyrene, a relatively inexpensive and widely available waste material, can reduce the demand for natural fine aggregates, leading to potential cost reductions in concrete production.

Conclussion:

We can select:

For Grade M10, Standard 1450 psi:-

i. Sample E - 1:3:6 – Weight less 8.73% - Strength not less
ii. Sample K - 1:2:4 – Weight less 12.1% - Strength not less
iii. Sample P - 1:1.5:3 – Weight less 18.50% - Strength not less

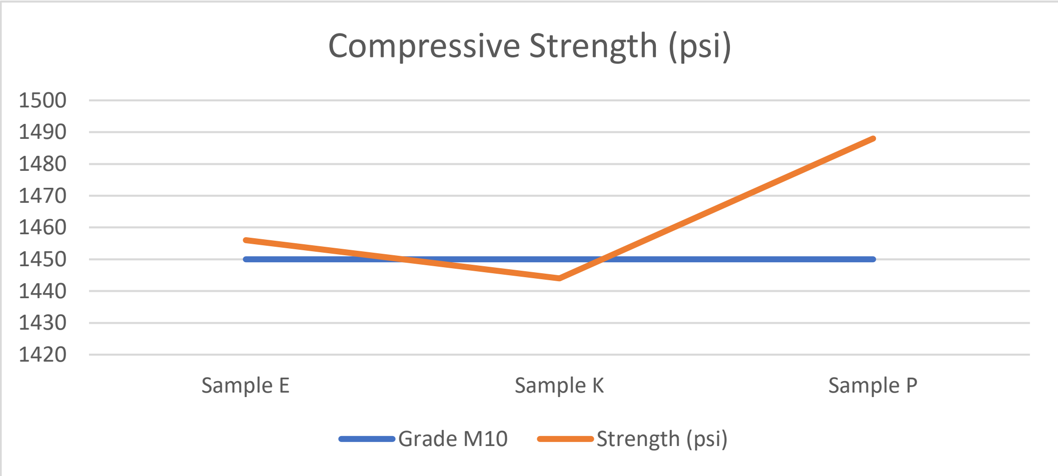

Fig: 5.1.1 Chart Bar Compressive Strength (psi).

For Grade M15, Standard 2175 psi:-

i. Sample I - 1:2:4 – Weight less 7.7% - Strength not less
ii. Sample N - 1:1.5:3 – Weight less 10.6% - Strength not less
iii. Sample O - 1:1.5:3 – Weight less 11.5% - Strength lessened by 8.32%

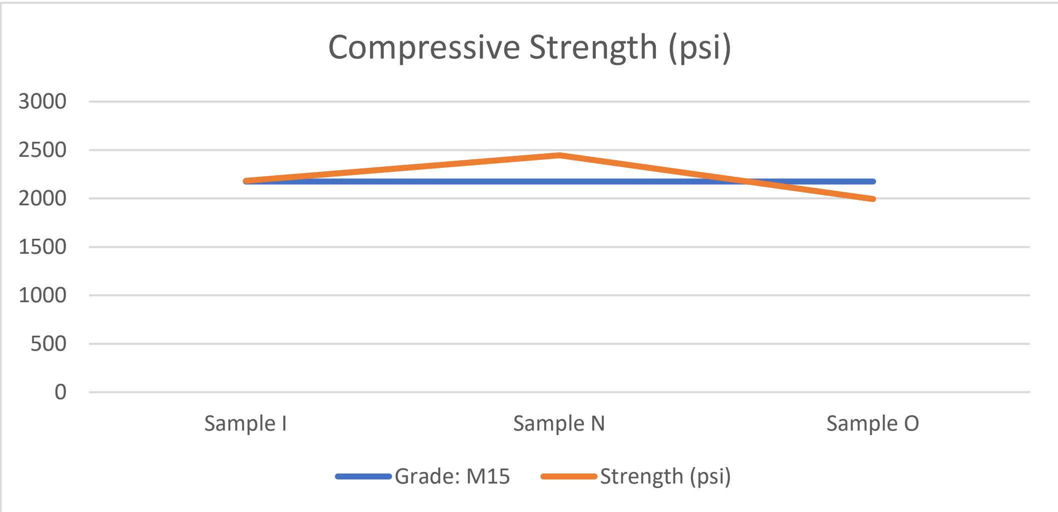

Fig: 5.1.2 Chart Bar Compressive Strength (psi).

<u>For Grade M20:</u>

For Grade M20

Standard 2900 psi

Sample M - 1:1.5:3 – Weight less 3.31% - Strength less-2.2%

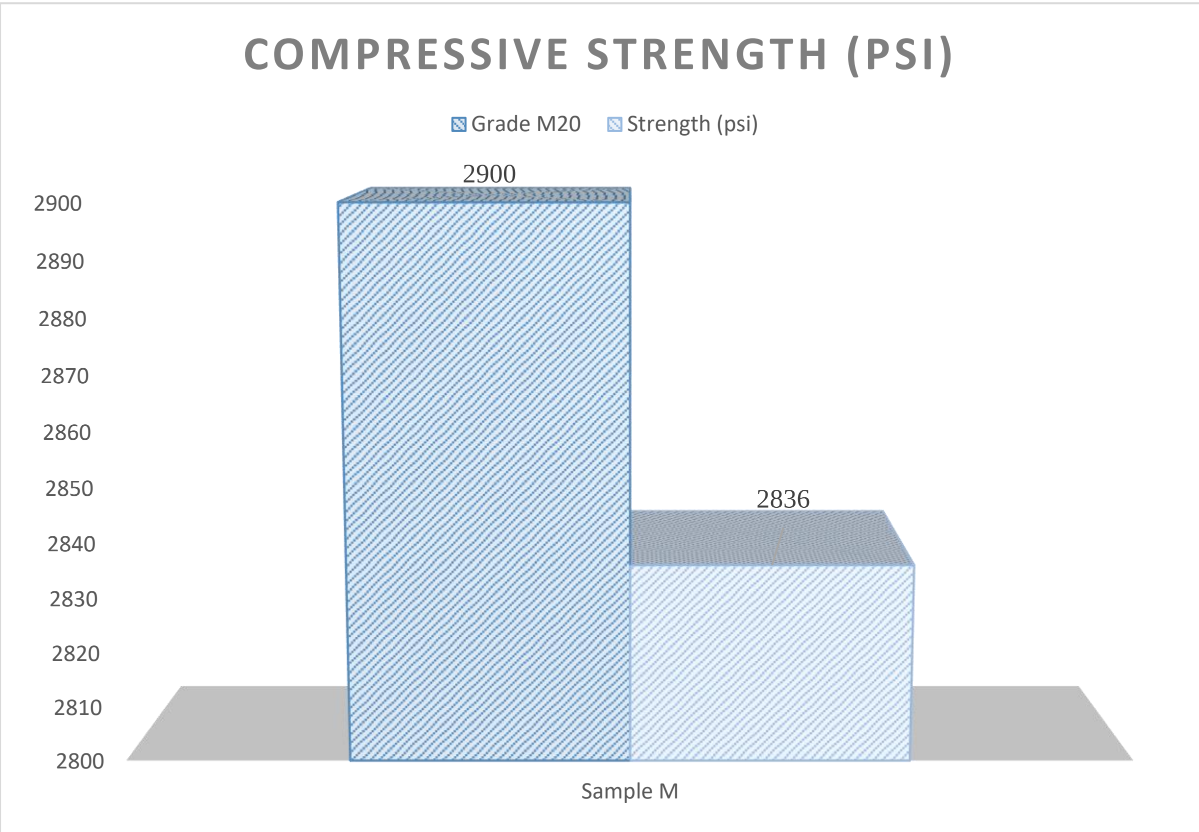

Fig: 5.1.3 Compressive Strength (psi).

5.2 Limitations:

The compressive strength of concrete, measured using a Universal Testing Machine (UTM), is a crucial parameter in assessing its structural integrity. However, there are several limitations to this testing method:

Sample Size:

The size of the concrete sample used for testing might not accurately represent the behavior of the entire structure. Variations in composition, curing conditions, and workmanship can lead to differences between lab-tested samples and real-world applications.

Surface Condition:

The surface condition of the concrete sample can significantly influence the test results. Imperfections, voids, or uneven surfaces can lead to stress concentrations, affecting the measured compressive strength.

Instrumentation and Calibration:

Proper calibration and maintenance of the Universal Testing Machine are essential for accurate measurements. Instrumentation errors can lead to erroneous results.

Moisture Content:

Moisture content in concrete can affect its strength properties. Improper curing or variations in moisture content between the core and surface of the sample can lead to inaccurate test results.

Age of Concrete:

The compressive strength of concrete typically increases with age due to continued hydration and curing. Testing at an early age may underestimate the ultimate strength of the concrete, while testing at later ages might not be feasible for practical reasons.

Operator Skill:

Proper operation and calibration of the UTM are essential for obtaining accurate results. Operator skill and experience can affect the reliability of the measurements. Inexperienced operators may introduce errors during setup or data interpretation.

Understanding these limitations is crucial for interpreting the results accurately and ensuring that the compressive strength values obtained from UTM testing reflect the actual behavior of the concrete in its intended application.

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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