INTERNATIONAL JOURNAL OF PROGRESSIVE RESEARCH IN ENGINEERING MANAGEMENT AND SCIENCE (IJPREMS)

e-ISSN : 2583-1062

Impact Factor: 5.725

www.ijprems.com
editor@ijprems.com

Vol. 04, Issue 05, May 2024, pp: 603-608

A REVIEW PAPER ON COMPARATIVE ANALYSIS OF MECHANICAL PROPERTIES IN CONCRETE THROUGH PARTIAL REPLACEMENT OF CEMENT WITH EGG SHELL POWDER AND RICE HUSK ASH

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ABSTRACT

This review study provides a detailed comparison of the mechanical characteristics of concrete obtained by partially substituting cement with egg shell powder (ESP) and rice husk ash (RHA). With the growing importance of sustainability in the construction sector, there has been a notable focus on investigating alternate materials for producing concrete. ESP and RHA are becoming increasingly attractive as supplemental cementitious materials since they are abundant, inexpensive, and have the potential to provide environmental benefits.

The review commences by analyzing the chemical composition and pozzolanic characteristics of ESP and RHA, emphasizing their capacity to interact with calcium hydroxide and aid in the creation of supplementary cementitious compounds in concrete. The research subsequently explores the impact of integrating ESP (Expanded Polystyrene) and RHA (Rice Husk Ash) on different mechanical characteristics of concrete, such as compressive strength, flexural strength, and durability.

The evaluated studies indicate that substituting a portion of cement with ESP and RHA can result in enhancements in the performance of concrete. Experimental research have demonstrated that both ESP and RHA can improve the compressive strength of concrete when utilized as partial replacements for cement. Optimal degrees of replacement have been established through these experiments. Moreover, the inclusion of ESP (Expanded Polystyrene) and RHA (Rice Husk Ash) has been discovered to have a beneficial effect on the flexural strength of concrete, hence enhancing its structural integrity and ability to withstand loads.

In addition, the review examines the impact of ESP and RHA on the durability characteristics of concrete, such as its capacity to resist chloride ion penetration, sulfate assault, and alkali-silica reaction. Research indicates that ESP (Electrochemical Surface Protection) and RHA (Rice Husk Ash) can reduce the harmful impact of aggressive substances on concrete buildings, leading to improved durability and longer service life.

In summary, this analysis highlights the capacity of ESP and RHA to serve as environmentally friendly substitutes for traditional cement in the manufacturing of concrete. This work offers useful insights for researchers, engineers, and practitioners who aim to optimize concrete formulas and encourage environmentally responsible construction practices by explaining how these formulations affect mechanical qualities and durability. Furthermore, it suggests opportunities for additional research to fully investigate the potential and application of ESP and RHA in the field of concrete technology.

Key Words: Fly ash, Egg shell waste, slump, compressive strength, flexural strength, split tensile strength, water absorption and sulphate attack test.

1. INTRODUCTION

Concrete, being the predominant construction material on a global scale, has consistently experienced innovation and enhancement to cater to the changing requirements of contemporary construction methods. As sustainability becomes increasingly important in the construction sector, there is a greater focus on investigating alternate materials and practices that can minimize environmental harm while still maintaining or improving performance. An avenue of investigation involves partially replacing cement with supplemental cementitious materials (SCMs) obtained from waste or residues of other industries. Egg shell powder (ESP) and rice husk ash (RHA) have gained significant interest in this context as possible materials for improving the mechanical characteristics of concrete while simultaneously reducing its carbon emissions.

This introduction establishes the context for a thorough review work that seeks to examine and contrast the mechanical characteristics of concrete obtained by partially substituting cement with ESP and RHA. This review aims to analyze the existing literature to gain a deeper understanding of the usefulness of ESP and RHA as alternative cementitious materials. Additionally, it aims to assess the impact of these materials on the performance and sustainability of concrete.

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Using waste materials or byproducts in concrete manufacturing is a viable method to tackle environmental and economic concerns. ESP and RHA are plentiful agricultural byproducts that are produced in significant amounts worldwide. ESP is derived from discarded egg shells, whereas RHA is made from the combustion of rice husks in rice mills. Both materials have garnered interest because of their pozzolanic qualities, which allow them to chemically react with calcium hydroxide in the presence of water and create extra cementitious compounds. This process enhances the strength and durability of concrete.

The purpose of this review is to assess and compare the mechanical characteristics of concrete that includes ESP and RHA as partial substitutes for cement. It is crucial to comprehend the impact of these substitute elements on attributes including compressive strength, flexural strength, and durability in order to enhance concrete mixtures and encourage sustainable construction methods.

The review commences by presenting a concise summary of the chemical composition and pozzolanic properties of ESP and RHA. Comprehending the chemical characteristics of these substances is essential for evaluating their responsiveness and possible impact on the performance of concrete. ESP is mainly composed of calcium carbonate (CaCO3), whereas RHA has a significant concentration of silica. Both materials have demonstrated pozzolanic activity, which qualifies them as acceptable options for replacing cement in concrete.

The review explores the mechanical qualities of concrete that include the incorporation of ESP (Electrostatic Precipitator) and RHA (Rice Husk Ash), after the previous discussion on chemical properties. Several experiments have examined the impact of partially replacing cement with these substances on the strength of concrete, yielding different outcomes as documented in the literature. The compressive strength of concrete is a crucial factor in evaluating its structural performance. Numerous research have examined the compressive strength of concrete that includes electric arc furnace slag powder (ESP) and rice husk ash (RHA) at various levels of substitution. In addition, the assessment evaluates the flexural strength of concrete, which is crucial for determining its capacity to endure bending loads.

Moreover, the review examines the durability characteristics of concrete that includes ESP and RHA. When it comes to concrete construction, durability is an important factor to consider, especially in challenging conditions where structures are exposed to corrosive substances like chloride ions, sulfates, and alkalis. Research has examined the ability of concrete containing ESP and RHA to withstand harmful substances, offering valuable information on how they can improve the long-term durability of concrete structures.

Furthermore, the assessment examines practical factors including workability and cost-effectiveness, in addition to mechanical and durability features. Workability is a crucial factor for the smoothness of placing and compacting concrete during construction. Researchers have conducted research to analyze the workability of concrete mixes that include Electric Arc Furnace Slag (ESP) and Rice Husk Ash (RHA) to determine their suitability for different building purposes. Cost-effectiveness is a vital factor to consider when deciding to use alternative materials in the building business. The adoption of these materials should be economically feasible for widespread application.

This paper seeks to comprehensively analyze the mechanical properties of concrete when cement is partially replaced with ESP and RHA. This study aims to analyze existing literature and identify areas where information is lacking. Its purpose is to provide guidance for future research endeavors and offer insights for decision-making in sustainable concrete building. In conclusion, the results of this analysis could potentially aid in the creation of improved concrete mixtures that achieve a harmonious balance between performance, sustainability, and cost-effectiveness in construction methods.

2. LITERATURE REVIEW

Gajjar and Zala conducted a study in 2018 to examine the impact of partially replacing cement with egg shell powder (ESP) on M25 grade concrete. The study maintained a consistent level of ground granulated blast furnace slag (GGBS) at 25%. The researchers analyzed different amounts of ESP substitution, ranging from 0% to 30% with increments of 5%. An important discovery from their research was the correlation between the increase in the proportion of ESP used as a substitute for cement and the decrease in the slump value of the concrete. The slump value is a metric that quantifies the uniformity and workability of fresh concrete. Higher slump values correspond to increased workability. The drop in slump value seen with the increasing replacement of ESP indicates a deterioration in the workability of the concrete as more ESP was added to the mixture. The reason for this phenomena can be ascribed to the smaller particle size and greater water requirement of ESP in comparison to cement. This could have caused an increase in water absorption and a decrease in lubrication between particles, ultimately leading to lower workability. This discovery has practical consequences for the formulation of concrete mixes and the implementation

of construction techniques. Engineers and concrete producers must thoroughly evaluate the intended slump value and workability criteria when integrating ESP as a partial substitute for cement. Modifications to the mixture proportions, such as augmenting the water-cement ratio or incorporating water-reducing admixtures, might be required in order to preserve the acceptable ease of handling while attaining the desired extent of ESP substitution. The study conducted by Gajjar and Zala offers significant insights into the impact of ESP on the workability of concrete mixtures. This research contributes to the comprehension of sustainable concrete manufacturing methods and the improvement of mix designs to achieve better performance and durability.

In 2017, Afolayan conducted a study to examine the effects of substituting egg shell in concrete with different amounts of egg shell powder (ESP), ranging from 0% to 30%. The concrete mix ratios used were 1:2:4 and the water-cement ratio was 0.55. The study sought to evaluate the impact of Electrostatic Precipitator (ESP) on the characteristics of concrete, with a specific emphasis on its workability. An important discovery of the study was that the existence of ESP resulted in a higher level of workability in comparison to traditional concrete. The workability of the concrete mixtures improved as the proportion of ESP employed as a substitute for egg shell rose from 0% to 30%. The higher workability can be due to the smaller particle size and larger surface area of ESP. This allows for better arrangement of particles and improved lubrication between them, resulting in smoother flow and easier placement. The results of this study enhance our comprehension of how ESP affects specific characteristics of concrete, including its workability, and emphasize the potential advantages it offers in the manufacturing of concrete. These insights are helpful for the process of designing concrete mixes and carrying out construction activities. They help in creating concrete formulas that are more sustainable and easier to work with.

Asman Afizah S N et al. 2017, performed a comparative analysis of slump test findings for M30 grade concrete. The study examined the effects of integrating rice husk ash (RHA) and egg shell powder (ESP) at different replacement percentages. The researchers assessed various concrete compositions with replacement ratios of RHA:ESP at 2%:8%, 4%:6%, and 6%:4%. Their investigation demonstrated that substituting cement with both RHA and ESP resulted in an enhancement of the concrete's workability. The slump test findings demonstrated that the workability of the concrete mixtures improved as the proportions of RHA and ESP rose. The researchers determined that the ideal proportions for replacing egg shell and rice husk in concrete were 4% and 6% respectively. These percentages were found to achieve the necessary workability of the concrete while also preserving its performance. This study highlights the potential of using RHA (Rice Husk Ash) and ESP (Electric Arc Furnace Steel Slag Powder) as additional ingredients in the manufacturing of concrete. It provides valuable information on the ideal levels at which these components can be replaced in order to improve the workability of concrete without compromising its quality. These findings have significant value in providing information for creating specific concrete mix designs and encouraging the use of sustainable construction methods.

Karum Kumar and Priyanka (2017) conducted a study to examine how the addition of copper slag (CS) and egg shell powder (ESP) affects the results of the slump test for M30 and M40 grade concrete. The researchers analyzed different proportions of substitution for both materials, ranging from 0% to 30% based on weight. Their research showed that the slump cone value rose when copper slag and egg shell powder were gradually added, reaching a maximum at replacement levels of 25%. The data suggests that the workability of the concrete mixtures was enhanced when the proportions of both CS and ESP increased within the specified range.The findings indicate that the most effective degrees of substitution for achieving the desired workability, while using copper slag and egg shell powder as partial substitutes for cement, are between 0% and 25%. These insights are valuable for the design of concrete mixes and building methods, making it easier to develop concrete formulations that are both more sustainable and easier to work with.

Dhanalakshmi M et al. conducted a study in 2015 to examine the impact of using egg shell powder (ESP) and fly ash as substitutes for cement in concrete mixtures. The researchers analyzed different proportions of ESP, ranging up to 12.5%, in conjunction with amounts of fly ash replacement that varied from 0% to 30%.Their research revealed that as the proportion of ESP (expansive supplementary material) grew, the slump value (measure of workability) of the concrete reduced in comparison to the control sample. The drop in slump value indicates a decline in workability as the ESP content increases. Nevertheless, the inclusion of fly ash in the concrete mixtures led to a rise in the slump value. The rise in slump value due to the addition of fly ash indicates an enhancement in workability, which could potentially counterbalance the decline observed with increased ESP concentration. The results demonstrate the interaction between ESP and fly ash in affecting the workability of concrete mixtures and offer valuable insights for modifying concrete compositions to attain desired performance attributes.

In 2014, Doh Shu Ing conducted a study to explore the viability of using egg shell powder (ESP) as a filler material in concrete. The study evaluated different percentages of ESP, ranging from 0% to 20%. According to the study, the ideal proportion of ESP as a substance added to concrete was determined to be 20%, as it resulted in a slump value of 75mm. Conversely, the group that did not have ESP demonstrated a decline in value of 70mm. This indicates that ESP can be used as an additive in concrete to fill voids without absorbing excessive water, therefore improving its workability and potentially enhancing the qualities of the concrete.

Yerramala 2014 conducted a study to examine the characteristics of concrete when different proportions (ranging from 5% to 15%) of egg shell powder (ESP) were used as a substitute for cement. The study incorporated a slump test to evaluate the workability of the concrete mixtures.The results indicated that the slump values of concrete containing ESP were reduced, ranging from 5-12mm, in comparison to ordinary concrete. The fall in slump value indicates a deterioration in the workability of the concrete as the amount of ESP increases. The decreased workability of the concrete mix may be attributed to the smaller particle size and water absorption properties of ESP, which impact the flow and uniformity of the mixture. These findings offer valuable information about how ESP affects the workability of concrete mixtures and emphasize the significance of optimizing ESP content to achieve specific performance characteristics in concrete manufacturing.

In 2019, S. Sathvik and colleagues did a comparison study on M30 grade concrete. They investigated the effects of partially replacing egg shell powder (ESP) at different percentages (5%, 10%, 15%, 20%) with coconut fiber. The substitution of ESP up to 10% resulted in an increase in compressive strength. However, above this threshold, the compressive strength declined at 7, 14, and 28 days after curing. The study determined that incorporating 2.77% of an engineered superplasticizer (ESP) along with 0.6% coconut fiber resulted in greater tensile and compressive strength compared to regular concrete.

In a study conducted by Bhuvaneswari M in 2018, the mechanical characteristics of concrete were examined by including egg shells as a partial substitute for fine particles. The ESP was utilized in increments of 0%, 5%, 10%, 15%, 20%, and 25%. The compressive strength exhibited an initial increase of up to 20%, followed by a subsequent fall at 25%.

Gajjar R. A. and Zala J. (2018) conducted a study on concrete, examining the effects of including Electric Arc Furnace Steel Slag Powder (ESP) at various percentages ranging from 0% to 30% with intervals of 5%, as well as Ground Granulated Blast Furnace Slag (GGBS) at a percentage of 25%. Experiments were carried out at intervals of 7, 14, and 28 days using cubes measuring 150x150x150 in size. The study found that by substituting 15% of egg shell and 25% of GGBS, the compressive strength of the concrete rose by 35% compared to traditional concrete.

Ramathilagam.B.H et al. (2018), an experiment was carried out on M30 grade concrete. The researchers replaced a portion of the cement with egg shell powder, gradually increasing the replacement percentage from 0% to 25% at 5% intervals. The compressive strength exhibited a rise of 10% when egg shell was replaced, however, with further increases, the strength saw a decline. The increment was 13.4% greater than the increment of the control concrete.

Sehgal S. and Kaur A. (2018) conducted a study on M25 grade concrete, in which different percentages of egg shell powder (2.5%, 5%, 7.5%, and 10%) were used to substitute cement, along with the addition of silica fumes at a rate of 15%. The compressive strength initially exhibited a rise, but then declined upon further addition. The optimal amount was determined to be 2.5% for substituting cement with egg shell powder in the presence of silica fumes.

Anish G. and Pavani A. (2017) examined the impact of ESP and fly ash on concrete. The ESP was subjected to varying weight percentages (0%, 7%, 14%, 21%, 28%) and tests were performed on 150x150x150 cubes after 7 and 28 days. The compressive strength after 7 and 28 days of curing was greater than that of conventional concrete for 21% of fly ash and ESP. When the replacement rate exceeds 28%, the weight of each cube decreases by a maximum of 7%.

Bandhavya G.B et al. (2017) conducted an empirical investigation on the utilization of egg shell powder as a substitute for cement in concrete. The egg shell powder was employed in percentages of 0%, 5%, 10%, and 15% relative to the weight of the cement. After 3 days, the compressive strength of ordinary concrete was inferior to that of concrete containing egg shell powder. As the percentage of egg shell powder increased, the compressive strength decreased.

Babu A. et al. (2017), an experiment was performed to investigate the effects of substituting cement with ESP in M 20 grade concrete. The replacement percentages tested were 5%, 10%, 15%, 20%, and 25%. According to the report, substituting 5% of cement with ESP resulted in better strength compared to the regular concrete. However, the strength thereafter declined.

Kumar A. (2017), the use of egg shell powder was investigated as a partial replacement for cement in concrete. ESP was used as a partial replacement for cement, with proportions of 5%, 10%, and 15% based on the weight of the cement. The compressive strength of concrete exhibited a rise of up to 10% at curing ages of 7 and 28 days. However, when 15% replacement was introduced, there was a drop in compressive strength.

In 2017, Nivedhitha M. and Sivarija M. conducted an experiment to investigate the effects of replacing a portion of cement with egg shell powder and coconut shell powder. The replacement percentages used were 2.5%, 5%, and 15%. The compressive strength of concrete exhibited an improvement up to a 5% replacement, but experienced a drop at a 15% replacement.

Parkash A. and Singh R. (2017), an experiment was carried out on M20 grade concrete. The researchers replaced cement with egg shell powder at different percentages: 6%, 12%, 18%, and 24%. The compressive strength exhibited an increase of up to 12% at 7 and 28 days when replaced with egg shell powder. However, the compressive strength subsequently reduced upon additional addition of egg shell powder.

Patel J. S. et al. (2017) conducted a comprehensive analysis of previous research on the utilization of fly ash, RHA, and ESP in concrete. The commenters observed that the concrete's compressive strength was satisfactory when using RHA, and that ESP may be utilized as a substitute for cement, up to a maximum of 10% of the cement's weight.

3. CONCLUSIONS

From the study of literature review, the following initial conclusion can be drawn.

1. The incorporation of egg shell waste as a partial replacement for ordinary Portland cement (OPC) in concrete does not adversely affect the workability of the mixture. This ensures that the concrete remains easy to handle, place, and compact during construction processes, maintaining overall workability and facilitating proper consolidation.

2. Egg shell waste, when used as a substitute for OPC in concrete, leads to an increase in compressive strength as the curing period progresses. This enhancement is particularly notable up to a 10% replacement level of egg shell waste, indicating its potential to improve the structural performance and durability of the concrete over time.

3. Over the curing period, the flexural strength of concrete gradually increases, reaching its peak at the 10% replacement level of egg shell waste. This signifies improved resistance to bending stresses, demonstrating the ability of egg shell waste to enhance the structural integrity and load-bearing capacity of the concrete.

4. Similarly, the split tensile strength of concrete shows an upward trend with increasing curing age, with the highest strength observed at the 10% replacement level of egg shell waste. This trend parallels the findings for compressive strength, suggesting that egg shell waste contributes consistently to the improvement of mechanical properties, enhancing the overall performance and durability of the concrete mixture.

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