Partial Replacement of Cement with Rice Husk AshBasedGeopolymer Concrete with M40 Grade

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Abstract

This work constitutes Concrete is an important material for construction. Geopolymer concrete is a unique eco-friendly building material since it uses fly ash and alkali to replace OPC as the binding agent. To lessen the global warming effects of construction, fly ash is utilized instead of cement. This study presents findings from studies on steel-reinforced geopolymer concrete made from fly ash and rice husk ash. The goal of this study is to evaluate the effectiveness of geopolymer concrete made with different percentages of rice husk ash as a cement replacement. Compressive strength is shown to decrease as the percentage of rice husk ash in the material increases. In place of fly ash, RHA can be utilized in geopolymer concrete at a maximum substitution rate of 20%. The recycling of used materials is the project's main focus. Substituting rice husk ash for fly ash reduces the fresh concrete's workability, but a chemical addition can restore it.

Keywords: cement, rice husk ash, geopolymer, concrete, M40 grade.

I. INTRODUCTION

Concrete is the most widely used construction material due to its strength, durability, and versatility. However, the production of conventional cement-based concrete contributes to significant carbon dioxide emissions and utilizes large quantities of non-renewable resources. To address these environmental concerns, researchers and engineers are exploring alternative cementitious materials that can reduce the environmental impact of concrete production.

One such alternative is geopolymer concrete, which is a type of concrete that utilizes geopolymers as a binder instead of traditional Portland cement. Geopolymers are inorganic binders formed by the chemical reaction between alumina-silicate materials and alkaline activators. This technology offers the potential for reducing greenhouse gas emissions and utilizing waste materials as a substitute for cement.

This research focuses on the partial replacement of cement with rice husk ash (RHA) in the production of geopolymer concrete. Rice husk ash is an agricultural waste material that is abundantly available and often discarded as waste. By incorporating RHA into geopolymer concrete, the study aims to achieve sustainable and environmentally friendly construction materials.

The research specifically investigates the use of M40 grade concrete, which corresponds to a characteristic compressive strength of 40 MPa. The M40 grade is commonly used in various structural applications that require high strength and durability. The objective is to evaluate the mechanical properties, durability, and microstructure of the geopolymer concrete with partial replacement of cement with RHA.

The study includes experimental investigations to determine the optimum replacement level of cement with RHA in geopolymer concrete. Various mix proportions are considered to analyze the effects of RHA on compressive strength, split tensile strength, flexural strength, and other mechanical properties. Additionally, durability tests such as water absorption, chloride permeability, and carbonation resistance are conducted to assess the performance of the geopolymer concrete in different environmental conditions.

Furthermore, the microstructure of the geopolymer concrete is analyzed using techniques such as scanning electron microscopy (SEM) and X-ray diffraction (XRD) to understand the reaction mechanisms and bonding characteristics of the geopolymer matrix.

The findings of this research are expected to provide valuable insights into the feasibility and effectiveness of using RHA as a partial replacement for cement in geopolymer concrete with an M40 grade. The results will contribute to the development of sustainable concrete technology, reduce reliance on traditional cement, and promote the utilization of agricultural waste materials in the construction industry.

By exploring alternative cementitious materials and investigating their performance in geopolymer concrete, this research contributes to the advancement of environmentally friendly construction practices and supports the goal of achieving sustainable infrastructure development.

LITERARURE SURVY

[1] Tawfik, S., Ghorab, H. Y., & El-Badawy, S. M. (2019). “Utilization of Rice Husk Ash as Partial Replacement of Cement in Geopolymer Concrete”. This study investigates the effect of partial replacement of cement with rice husk ash (RHA) in geopolymer concrete. The authors explore different percentages of RHA substitution and evaluate the mechanical properties and microstructure of the resulting geopolymer concrete. They conclude that RHA can effectively replace cement up to a certain percentage, enhancing the strength and durability of the geopolymer concrete.

[2] Zhang, Z., Chen, B., Poon, C. S., & Xu, H. (2020). “Geopolymer Concrete with Partial Replacement of Cement by Rice Husk Ash: Mechanical Properties and Microstructure”. In this research, the authors investigate the influence of various RHA replacement levels on the mechanical properties and microstructure of geopolymer concrete. They conduct comprehensive experimental tests, including compressive strength, split tensile strength,

and scanning electron microscopy analysis. The study demonstrates that incorporating RHA improves the strength and enhances the microstructural characteristics of geopolymer concrete.

[3] Singh, N. B., Mohd, N. M., & Azmi, N. H. (2016). "Strength and Microstructure of Fly Ash Based Geopolymer Concrete Containing Rice Husk Ash as Partial Replacement of Fly Ash". This study focuses on the use of rice husk ash as a partial replacement for fly ash in geopolymer concrete. The authors examine the effect of RHA on the mechanical properties, microstructure, and hydration characteristics of the geopolymer concrete. The results indicate that the incorporation of RHA leads to improved strength and denser microstructure in the geopolymer concrete.

[4] Oner, A., & Akyuz, S. (2016). "An Experimental Study on the Effects of Rice Husk Ash on the Properties of Geopolymer Concrete". The authors investigate the influence of rice husk ash on the properties of geopolymer concrete, including workability, compressive strength, and durability. Various RHA replacement levels are examined, and the results demonstrate that RHA can enhance the workability and mechanical properties of the geopolymer concrete. The study also addresses the effect of RHA on the durability aspects such as water absorption and chloride penetration.

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PROBLEM STATEMENT

The production of conventional cement-based concrete contributes to significant carbon dioxide emissions and relies on non-renewable resources. To address these environmental concerns, there is a need to explore alternative cementitious materials that can reduce the environmental impact of concrete production. Rice husk ash (RHA) is an abundantly available agricultural waste material that can potentially be utilized as a partial replacement for cement in geopolymer concrete.

However, there is a lack of comprehensive studies focusing on the use of RHA as a partial replacement for cement in geopolymer concrete with a specific target grade, such as M40. The M40 grade of concrete is commonly used in various structural applications that require high strength and durability.

The problem statement for this research is to investigate the feasibility and effectiveness of utilizing RHA as a partial replacement for cement in the production of geopolymer concrete with an M40 grade. This involves determining the optimum replacement level of cement with RHA in geopolymer concrete to achieve the desired mechanical properties, durability, and microstructure.

LIMITATIONS

- **Optimum replacement level:** Determining the optimal percentage of cement replacement with rice husk ash (RHA) in geopolymer concrete for achieving the desired mechanical properties of M40 grade concrete may be challenging. The optimal replacement level may vary depending on factors such as the properties of the RHA, the alkaline activator used, and the specific mix design parameters. The study may need to conduct a series of experiments to identify the most suitable replacement level.

- **Availability and quality of RHA:** The availability and quality of RHA may vary based on factors such as the source of the rice husk, the combustion process, and the processing techniques. Inconsistencies in RHA quality may affect the performance and properties of the geopolymer concrete. Obtaining a reliable and consistent supply of high-quality RHA may pose a limitation in some regions or specific projects.

- **Durability considerations:** While geopolymer concrete has shown promising durability properties, the durability performance of geopolymer concrete with partial replacement of cement with RHA needs to be thoroughly investigated. The research may need to focus on assessing the long-term durability aspects, such as resistance to freeze-thaw cycles, alkali-silica reaction, and long-term aging effects.

- **Standardization and guidelines:** Geopolymer concrete is still an emerging technology, and there may be a lack of standardized guidelines and specifications specifically addressing the use of RHA in geopolymer concrete with an M40 grade. The absence of standardized procedures may introduce challenges in comparing and replicating the results across different studies.

- **Cost considerations:** The cost of RHA and the associated processing techniques may affect the economic feasibility of using RHA as a partial replacement for cement in geopolymer concrete. The research should consider the cost implications and compare them with conventional concrete to assess the cost-effectiveness of geopolymer concrete with RHA.

- **Practical implementation challenges:** Implementing geopolymer concrete with RHA in real-world construction projects may face practical challenges, including changes in construction practices, acceptance by industry stakeholders, and compliance with existing regulations and standards. These practical considerations should be acknowledged and addressed to facilitate the widespread adoption of geopolymer concrete with RHA.

Challenges

- ✓ **Optimal mix design:** Finding the optimal mix design for geopolymer concrete with partial replacement of cement with rice husk ash (RHA) to achieve the desired M40 grade can be challenging. It requires careful consideration of the proportions of RHA, activators, aggregates, and other additives to ensure the desired strength and durability are attained.
- ✓ **Variation in RHA properties:** The properties of RHA can vary depending on factors such as the source of rice husk, combustion process, and post-processing techniques. These variations can affect the reactivity and performance of RHA in geopolymer concrete. Consistency in RHA properties is essential for achieving consistent results in concrete production.
- ✓ **Activation process:** Geopolymerization is a complex chemical process that involves the activation of alumina-silicate materials with alkaline solutions. Finding the appropriate activation process, including the selection of alkaline activators and curing conditions, can be a challenge. The activation process needs to be carefully controlled to optimize the reaction kinetics and ensure the development of desirable geopolymer products.
- ✓ **Durability considerations:** Geopolymer concrete with RHA needs to demonstrate satisfactory durability properties. Assessing the resistance to environmental factors such as freeze-thaw cycles, alkali-silica reaction, and chemical attack requires careful testing and evaluation. Developing geopolymer concrete formulations that exhibit adequate durability performance can be challenging.
- ✓ **Availability and quality of RHA:** The availability and quality of RHA can vary regionally and seasonally. Access to a consistent supply of high-quality RHA in sufficient quantities can be a challenge. In some regions, the production and procurement of RHA may be limited, which can impact the scalability and widespread adoption of geopolymer concrete with RHA.
- ✓ **Cost considerations:** The cost of RHA and the additional processing steps required for its utilization in geopolymer concrete should be carefully evaluated. The cost-effectiveness of geopolymer concrete with RHA needs to be assessed in comparison to conventional cement-based concrete, taking into account factors such as material costs, production efficiency, and long-term performance.
- ✓ **Construction industry acceptance:** Geopolymer concrete is still relatively new in the construction industry. The acceptance, understanding, and adoption of geopolymer concrete with RHA may face resistance or skepticism from industry stakeholders, including

contractors, engineers, and regulatory bodies. Educating and raising awareness about the benefits and performance of geopolymer concrete can help address these challenges.

Properties

- **Compressive Strength:** The compressive strength of geopolymer concrete with partial replacement of cement with rice husk ash (RHA) is a critical property. M40 grade concrete typically requires a minimum compressive strength of 40 MPa. The research aims to determine the optimal replacement level of cement with RHA to achieve the desired compressive strength while maintaining the structural integrity of the concrete.
- **Split Tensile Strength:** Split tensile strength is another important mechanical property of geopolymer concrete. It measures the ability of the concrete to resist tensile forces. The research investigates the split tensile strength of geopolymer concrete with RHA to ensure it meets the required specifications for M40 grade concrete.
- **Flexural Strength:** Flexural strength is the measure of the concrete's ability to resist bending or flexing forces. It is crucial for structural elements that experience bending loads. The research examines the flexural strength of geopolymer concrete with RHA to assess its suitability for M40 grade applications.
- **Durability:** Geopolymer concrete with RHA needs to exhibit satisfactory durability properties. This includes resistance to factors such as freeze-thaw cycles, chemical attack, and abrasion. The research evaluates the durability performance of geopolymer concrete with RHA to ensure it can withstand the anticipated environmental conditions over the service life of the structure.
- **Water Absorption:** Water absorption is an indicator of the porosity of concrete and its ability to resist water penetration. Lower water absorption is desirable to prevent potential damage caused by moisture ingress. The research investigates the water absorption characteristics of geopolymer concrete with RHA to assess its moisture resistance properties.
- **Chloride Permeability:** Chloride ions can penetrate concrete and cause corrosion of reinforcement, leading to structural deterioration. The research examines the chloride permeability of geopolymer concrete with RHA to determine its resistance to chloride ingress, particularly in aggressive environments.
- **Carbonation Resistance:** Carbonation occurs when carbon dioxide reacts with the alkaline compounds in concrete, reducing its alkalinity and potentially compromising the integrity of the structure. The research assesses the carbonation resistance of geopolymer concrete with RHA to ensure its long-term durability in carbonation-prone environments.

- **Microstructure:** The microstructural analysis of geopolymer concrete with RHA provides insights into the reaction mechanisms and bonding characteristics. Techniques such as scanning electron microscopy (SEM) and X-ray diffraction (XRD) can be employed to examine the geopolymer matrix and identify the formation of desirable mineral phases.

II. METHODOLOGY

Partial Replacement of Cement

Partial replacement of cement refers to the practice of substituting a portion of cement in concrete or mortar mixes with alternative materials. This approach is aimed at improving certain properties of the mixture or reducing environmental impact. There are several common materials used for partial replacement of cement:

- **Fly Ash:** Fly ash is a byproduct of coal combustion in power plants. It is commonly used as a partial replacement for cement in concrete. Fly ash improves workability, reduces heat generation during hydration, and enhances long-term strength and durability.

Figure 1: Fly Ash

- **Slag:** Ground granulated blast furnace slag (GGBFS) is a byproduct of iron production in blast furnaces. It can be used as a partial cement replacement to improve the workability, strength, and durability of concrete. Slag also reduces the heat of hydration and provides better resistance to chemical attack.

Figure 2: Slag

- **Silica Fume:** Silica fume is a highly reactive pozzolanic material, which is a byproduct of silicon and ferrosilicon alloy production. When used as a partial replacement for cement, silica fume improves the strength, durability, and impermeability of concrete. It also enhances resistance to chloride ion penetration and sulfate attack.

Figure 3: Silica Fume

- **Rice Husk Ash:** Rice husk ash (RHA) is obtained from the combustion of rice husks. It contains high amounts of silica and can be used as a partial replacement for cement. RHA improves workability, reduces water demand, enhances the strength, and reduces the risk of alkali-silica reaction in concrete.

Figure 4: Rice Husk Ash

- **Natural Pozzolans:** Natural pozzolans, such as volcanic ash, calcined clay, and certain types of shale, can be used as partial replacements for cement. These materials have pozzolanic properties, reacting with calcium hydroxide to form additional cementitious compounds, improving strength, and reducing permeability.

The partial replacement of cement with these alternative materials can have several benefits, including improved workability, increased long-term strength, reduced environmental impact, and lower costs. However, it's essential to consider the specific characteristics of the alternative material, the desired properties of the mixture, and any potential interactions or limitations when determining the appropriate replacement ratio.

Rice husk ash (RHA)

Rice husk ash (RHA) can be used as a pozzolanic material in the production of geopolymer concrete. Geopolymer concrete is a type of concrete that utilizes a geopolymer binder instead of Portland cement. It offers several advantages such as reduced carbon dioxide emissions, improved durability, and enhanced chemical resistance.

To produce geopolymer concrete using RHA, the following steps can be followed:

- ✓ **Raw Materials:** The main components required are rice husk ash, alkaline activators (typically a combination of sodium hydroxide and sodium silicate), aggregates (such as fine and coarse aggregates), and water.
- ✓ **Mix Design:** A mix design needs to be developed for the desired M40 grade of concrete. This involves determining the appropriate proportions of RHA, alkaline activators, and aggregates to achieve the desired strength and workability. The mix design process may involve laboratory testing and optimization.
- ✓ **Mixing:** The dry components, including RHA and aggregates, are typically mixed first. Then, the alkaline activators are added gradually while continuing to mix. Sufficient mixing is essential to ensure a homogeneous mixture.
- ✓ **Casting:** The geopolymer concrete mixture is poured into the desired molds or formwork. Proper compaction is necessary to remove air voids and achieve good density.
- ✓ **Curing:** Geopolymer concrete requires a curing period to gain strength. The curing conditions may vary depending on the specific geopolymer system used. Generally, it involves maintaining the concrete at a controlled temperature and humidity for a specified duration.
- ✓ **Testing:** After the curing period, the geopolymer concrete specimens can be tested to evaluate their compressive strength, flexural strength, density, and other relevant properties. These tests can verify if the concrete meets the desired M40 grade requirements.

It's important to note that the mix design and production process for rice husk ash-based geopolymer concrete may vary based on factors such as the specific properties of the RHA, the type and concentration of alkaline activators, and other materials used. It is recommended to consult with concrete technologists or experts with experience in geopolymer concrete to ensure the appropriate mix design and production practices are followed.

Black rise husk ash (BRHA)

Black rise husk ash (BRHA) refers to the ash generated from the combustion of black rice husks. Black rice, also known as forbidden rice or purple rice, is a type of rice that is deep black or purple in color due to its high anthocyanin content.

When black rice husks are burned or combusted, the resulting ash is called black rise husk ash. This ash contains various minerals and nutrients that were present in the rice husks. It typically has a dark color due to the pigments present in black rice.

BRHA has gained attention in recent years as a potential agricultural resource and soil amendment. It can be used as a fertilizer or soil conditioner due to its nutrient content, including potassium, silica, calcium, magnesium, and trace elements. Additionally, the high silica content in BRHA can benefit plant growth and help improve soil structure.

Research suggests that BRHA may have several benefits when applied to soils, including increased nutrient availability, improved water retention, enhanced soil fertility, and reduced soil acidity. It may also have the potential to enhance plant growth, root development, and crop yield.

Table 1: Chemical Components

Chemical Component	Approximate Composition Range
Silica (SiO2)	85-95%
Carbon (C)	1-7%
Potassium (K2O)	1-3%
Sodium (Na2O)	0.5-2%
Calcium (CaO)	0.5-2%
Trace Elements	Varies depending on source

III. RESULTS & DISCUSSION

Material Collection and Preparation:

Obtain the required quantities of cement, rice husk ash, fine aggregate (sand), coarse aggregate (gravel), and water. Collect representative samples of rice husk ash and perform preliminary tests to determine its chemical composition and physical properties. Pre-treat the rice husk ash, if necessary, to remove impurities or unwanted materials. Prepare the geopolymer binder solution by activating the rice husk ash with an alkaline activator, such as sodium hydroxide (NaOH) or potassium hydroxide (KOH).

Mix Design:
Conduct a mix design process to determine the proportions of cement, rice husk ash, fine aggregate, and coarse aggregate to achieve the desired M40 grade of concrete. Consider the target compressive strength, workability requirements, and other specific project constraints while designing the mix.

Mixing Procedure:
Dry mix the cement, rice husk ash, fine aggregate, and coarse aggregate in the required proportions. Gradually add the geopolymer binder solution to the dry mix while continuously mixing to ensure proper dispersion and uniformity. Adjust the water content as needed to achieve the desired workability of the concrete mix.

Casting and Curing:
Pour the freshly mixed geopolymer concrete into molds or formwork, ensuring proper compaction to eliminate voids and air pockets. Cover the molds to prevent moisture loss and allow the concrete to cure under controlled conditions. Maintain the curing temperature and humidity as per the geopolymer concrete specifications to promote optimal strength development and durability.

Testing and Evaluation:

Figure 6: Casting and Curing

After the specified curing period, demold the geopolymer concrete specimens and prepare them for testing. Conduct various tests, including compressive strength, flexural strength, and durability tests, according to relevant standards and procedures. Record and analyze the test results to evaluate the performance of the geopolymer concrete with varying percentages of rice husk ash replacement.

Figure 7: Compression testing machine

Table 2: Compressive strength test for GPC of 8MNaOH

Specimen No.	Compressive strength at 3rd day (MPa)	Compressive strength at 7th day (MPa)	Compressive strength at 28th day (MPa)
1	17.7	18.6	22.4
2	17.5	18.5	22.7

3	17.34	19.3	23.2
Average strength	17.51	18.8	22.76

From Table 2 the average compressive strength of the test specimen increased. It strength of the test specimen is increased. It shows that with the progress of curing, strength of geo-polymer concrete increases. The percentage increase in strength from 3 to 28days curing time is approximately 35%. Shows that with the progress of curing, strength of geopolymer concrete increases. The percentage increase in strength from 3 to 28 days curing time approximately 23%.

Table 3: Compressive strength test for GP Cof10M NaOH.

S. No	Compressive strength at 3rd day (MPa)	Compressive strength that 7th day (MPa)	Compressive strength at 28th day (MPa)
1	18.5	20.4	24.9
2	18.9	21.2	24.1
3	18.2	20.9	24.6
Average strength	18.53	20.83	24.53

From Table 3 the average compressive strength of the test specimen is increased. It shows that with the progress of curing, strength of geo-polymer concrete increases. The increase in strength is approximately 24% for the curing time of 3 and 28 days. Compressive strength test for GPC of 12 M NaOH.

Table 4: The average compressive strength

S. No	Compressive strength at 3rdday (MPa)	Compressive strength at 7thday (MPa)	Compressive strength at 28th day (MPa)
1	20.3	25.5	31.6
2	19.9	24.9	30.9
3	20.5	24.6	31.4
Average strength	20.3	25	31.3

From Table 4 the average compressive strength of the test specimen is increased. It shows that with the progress of curing, strength of geo-polymer concrete increases. The percentage increase in strength from 3 to 28days curing time is approximately 35%. Compressive strength test for GPC of 14 M NaOH.

Table 5: The average compressive strength

S. No	Compressive strength at 3rd	Compressive strength at 7th	Compressive strength at 28th
	day (MPa)	day (MPa)	day (MPa)
1	22.6	28.7	35.2
2	23.3	28.2	36.7
3	23.4	29.2	35.9
Average strength	23.1	28.7	35.93

From Table 5 the average compressive strength of the test specimen is increased. It shows that with the progress of curing, strength of geo-polymer concrete increases. The percentage increase in strength from 3 to 28days curing time is approximately 35%.

Compressive strength results

The compressive strength results of different mixes are given by fig. In the present investigation compressive strength of concrete produced by replacing Cement by Rice Husk Ash without addition of Super plasticizer (0%, 10%, 20%, 30%, 40%and50%) adding.

Table 6: The compressive strength results of different mixes

Vol of Cement	Vol of RHA	Cube Compressive Strength that 7 Days (N/mm^2)		
		Cube 1	Cube 2	Cube 3
100%	0%	25.76	25.25	26.02
90%	10%	26.97	27.15	26.76
80%	20%	28.73	28.61	28.35
70%	30%	28.95	29.07	29.15
60%	40%	29.45	29.34	29.66
50%	50%	23.86	24.06	23.67

Table 7: Compressive strength of concrete with admixture

Vol of Cement	Vol of RHA	Cube Compressive Strength at 7 Days		
		Cube 1	Cube 2	Cube 3
100%	0%	25.76	25.25	26.02
90%	10%	27.97	28.45	28.67
80%	20%	29.83	29.31	29.65
70%	30%	29.95	30.07	30.15
60%	40%	30.95	30.54	30.66
50%	60%	24.36	25.06	25.67

Table 8: Compressive strength

S. No	NaOH concentration	Mix	Average compressive strength (MPa)			
			3 days	7 days	28 days	90 days
1	5 M	0%	56.2	60.5	62.7	65.5
		10%	58.9	61.4	62.9	66.1
		20%	39.9	41.4	43.3	45.4
		30%	17.8	18.6	19.1	21
2	8 M	0%	60.9	66.5	69.3	72.5
		10%	62.3	67.6	70.7	73.2
		20%	44.7	46.3	51.5	54.1
		30%	19.2	20.5	22.5	24.1
3	11 M	0%	67.1	72.1	74.3	77.4
		10%	69.1	75.1	76.8	80
		20%	49.5	54.5	56.6	59.5
		30%	21.4	22.8	23.4	25.7

Table 9: Splitting Tensile and Flexural Strength Tests

S. No	Mix	Split tensile			Flexural		
		3 days	7 days	28 days	3 days	7 days	28 days
1	0%	6.2	6.4	6.7	5.1	5.7	6.1

2	10%	6.5	6.7	6.9	5.7	6.3	7.1
3	20%	3.7	3.9	4.3	3.2	3.6	4.1
4	30%	0.8	0.9	1.1	0.9	1	1.3

Table 10: Durability Test

S. No	Mix	Weight loss (%)			Strength loss (%)		
		30 days	60 days	90 days	30 days	60 days	90 days
1	0%	0.25	3.45	6.1	3.3	10.25	15.2
2	10%	0.1	2.85	4.9	2.9	9.6	13.4
3	20%	0.1	3.1	5.2	3.2	10	13.9
4	30%	0.4	5.6	10.8	9.8	24	39.5

GRAPHICAL REPRESENTATION OF TEST RESULTS

The variation of compressive strength with molar concentration of NaOH is shown in fig 8. It shows that an increase in the compressive strength takes place as the molar concentration of NaOH solution is increased. Because the rate of leaching action of NaOH solution is increased due to the higher molar concentration of NaOH solution. The increase in strength from 8M to 12M is approximately 27% and 8M to 14M is 36%.

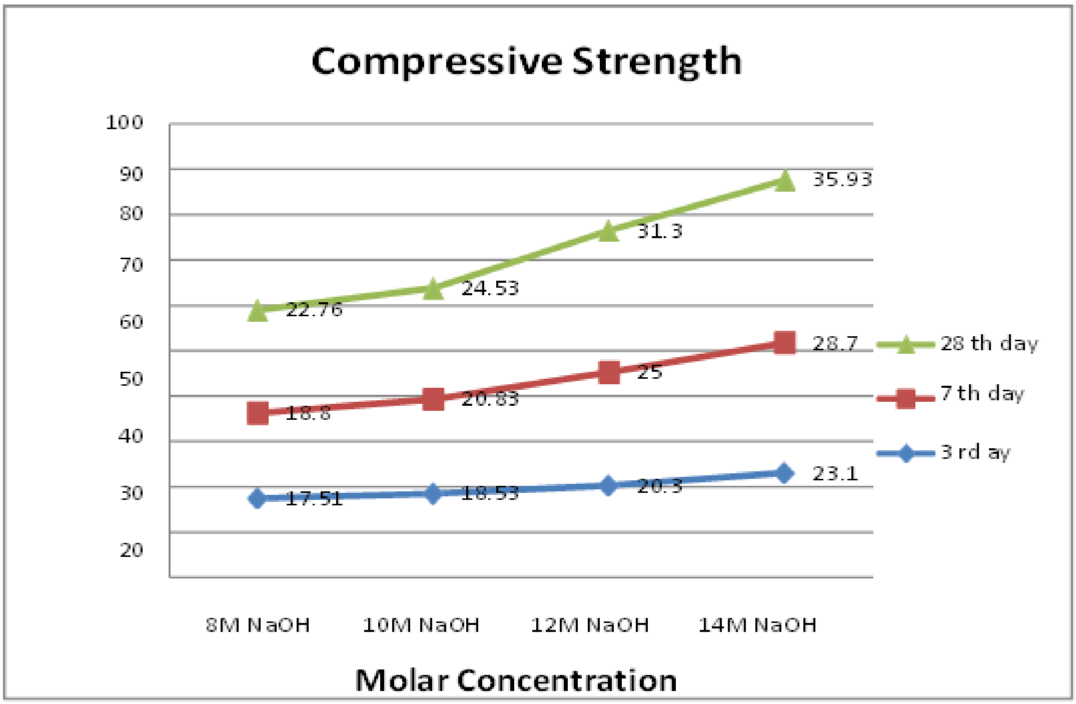

Figure 8: Variation of compressive strength with molar concentration of NaOH

The variation in total charge passed through cylindrical specimen is shown in Figure 8. The graph shows that the decrease in total charge passed through the cylindrical specimen of 12M concentration of NaOH solution if the age increases RCPT value decreasing. Charge passed in coulomb denotes the ingress of chloride ions through the concrete specimen.

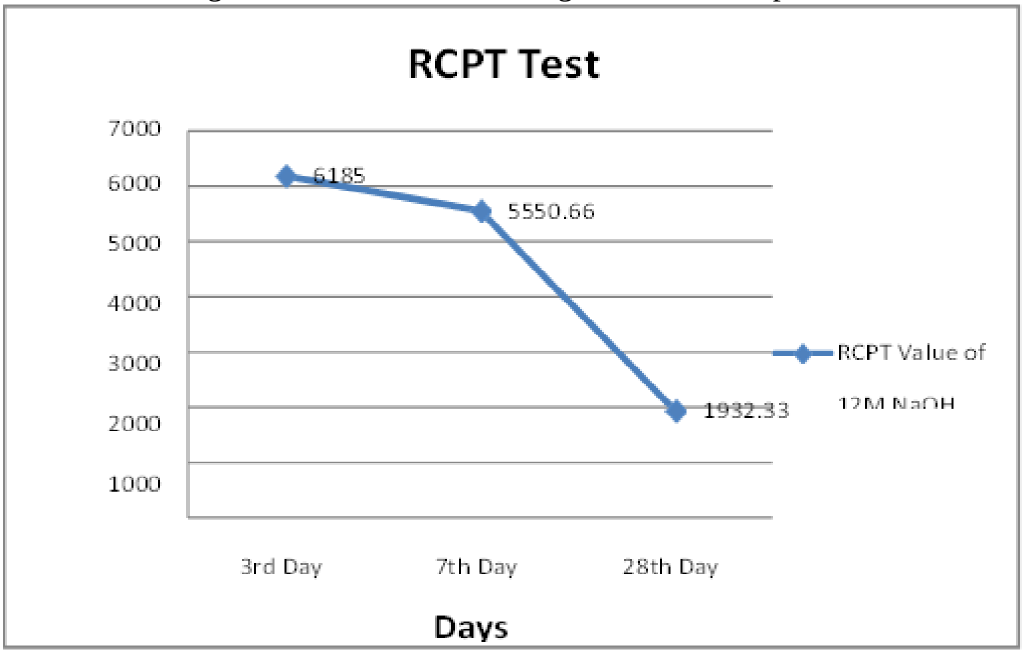

Figure 9: Variation in total charge passed through cylindrical specimen.

IV. CONCLUSION

The study investigates the effects of replacing cement with various percentages of rice husk ash (0%, 10%, 20%, 30%, 40%, and 50%) in M-40 grade concrete. The experimental findings indicate a significant enhancement in the physical and mechanical properties of concrete with a maximum replacement of 8% by weight with rice husk ash. This substitution leads to a 30% reduction in construction costs, particularly advantageous when cement availability is limited or distant. Moreover, the utilization of rice husk ash as a replacement material reduces the need for waste disposal, thereby mitigating environmental pollution. The investigation specifically focuses on the compressive strength of concrete, which exhibits notable improvement with the addition of rice husk ash. Additionally, the durability test results indicate consistent performance across the various replacement levels of rice husk ash.

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