WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review on Properties of Red Mud as a Partial Replacement of Cement with Hydrated Lime

Susheel Sharma [a], ***Dr. Vivek Soni*** [b]

M. Tech. Scholar [a], Assistant Professor [b], Madhyanchal Professional University**, Faculty of engineering & Technology, School of civil engineering Bhopal, M.P., India. **

ABSTRACT

An experimental study was conducted to evaluate the properties of concrete using red mud as a partial replacement for cement. Red mud is a by-product generated during the Bayer process for the extraction of alumina (corundum) from bauxite ore. This process is known for its low energy efficiency and results in the production of large quantities of fine, highly alkaline residues known as red mud.

The presence of compounds such as aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3) in red mud helps to compensate for the lack of similar components in limestone, the primary raw material used in cement production. Laboratory experiments were carried out to assess the strength characteristics of the concrete, including compressive strength, split tensile strength, and flexural strength.

In addition to strength tests, the workability of the concrete was evaluated using the slump cone test and the compaction factor test. These tests provided insight into how the inclusion of red mud affects both the fresh and hardened properties of concrete.

Key Words:- Red mud, aluminum oxide, iron oxide, slump cone test, hardened properties of concrete

Introduction

The rapid growth of the construction industry has led to an increased demand for cement, one of the primary components of concrete. However, the production of Ordinary Portland Cement (OPC) is energy-intensive and responsible for a significant portion of global carbon dioxide (CO_2) emissions. As sustainability becomes a central concern in modern construction, there is a pressing need to explore alternative, eco-friendly binders and supplementary cementations materials (SCMs) to reduce environmental impact and promote waste utilization.

Red mud, a highly alkaline industrial by-product generated during the Bayer process of alumina extraction from bauxite ore, is produced in massive quantities worldwide. Its disposal poses severe environmental challenges due to its high pH and fine particle size. However, its rich content of iron oxide, alumina, silica, and calcium makes it a potential material for cement replacement in concrete production.

This review investigates the properties and performance of red mud when used as a partial replacement of cement, especially in combination with hydrated lime. The addition of hydrated lime enhances the pozzolanic reactivity of red mud, potentially improving its binding properties. By evaluating the mechanical, physical, and durability characteristics of concrete mixtures containing red mud and hydrated lime, this review aims to assess their feasibility in sustainable construction practices.

Literature Review

Kubilay Kaptan et al (2024) there is an increasing global recognition of the need for environmental sustainability in mitigating the adverse impacts of cement production. Despite the implementation of various carbon dioxide (CO_2) mitigation strategies in the cement industry, such as waste heat recovery, the use of alternative raw materials and alternative fuels, energy efficiency improvements, and carbon capture and storage, overall emissions have still increased due to the higher production levels. The resolution of this matter can be efficiently achieved by the substitution of traditional materials with an alternative material, such as claimed clay (CC), construction and demolition waste (CDW), which have a significant impact on various areas of sustainable development, including environmental, economic, and social considerations. The primary objectives of employing CDW in the Portland cement production are twofold: firstly, to mitigate the release of CO_2 into the atmosphere, as it is a significant contributor to environmental pollution and climate change; and secondly, to optimize the utilization of waste materials, thereby addressing the challenges associated with their disposal. The purpose of this work is to present a thorough examination of the existing body of literature pertaining to the partial replacement of traditional raw materials by CDW and the partial replacement of Portland cement by CDW and to analyze the resulting impact on CO_2 emissions.

Inti Sudheer et al (2023) Industrialization and urbanization are the two worldwide phenomena. Though these are the necessity of the society and are mostly inevitable, the major ill effect of these global processes is the production of large quantities of industrial wastes and the problems related with their safe management and disposal. Red Mud is one such problem produced during the process for alumina production. This creates environmental problems, if not properly organized and stored. Efforts are in process to utilize it for constructive purpose. This project is one such work, in which red mud is tried, if it can be used in production of concrete. Now-a-days, concrete is the main construction material in most of the works. Reuse of materials which hamper the environmental conditions, will have dual advantage. One, is that the material will be consumed and second one is that economy can be obtained by utilizing the so called waste materials. Red mud posse's pozzolonic properties, by virtue of which it can be used as partial replacement of sand. In addition, partial replacement of cement with lime also proved economical. In the earlier literature, about 5% of replacement of cement with lime yielded optimum condition. In this project, properties of cement concrete with different proportions of red mud, with and without addition of 5% of lime are studied and analyzed. It is observed that addition of 15% red mud independently or with addition of lime, as partial replacement, proved to be a effective and economical.

Rohit Singh et al (2022) at the global level, the production of red mud (RM) is continuously increasing due to the rapid expansion of the aluminum industry. On average, approximately 0.8 to 1.5 tons of red mud are generated for every ton of alumina produced. With the aluminum industry growing swiftly, it is estimated that around 1.7 billion tons of red mud are produced worldwide each year. Owing to the use of sodium hydroxide (NaOH) during aluminum processing, red mud typically exhibits a highly alkaline pH ranging from 10.5 to 12.5.

This study investigates the incorporation of red mud as a partial replacement material in concrete. Concrete cube and beam specimens were prepared using recommended weight percentages of red mud and tested across various concrete grade levels. The experimental program focused on evaluating the compressive, flexural, and tensile strengths of red mud-modified concrete.

The results provide insights into the changes in the physical and mechanical properties of concrete resulting from the inclusion of red mud. This study contributes to the development of sustainable construction materials by exploring the beneficial reuse of industrial waste in concrete applications.

Mohammed Rizwan Raza et al (2021) the increasing global demand for aluminum has led to a significant rise in the production of red mud (RM), a byproduct of the Bayer process used in alumina extraction. On average, the production of one ton of alumina results in the generation of approximately 0.8 to 1.5 tons of red mud. With the rapid expansion of the aluminum industry, global red mud generation has reached an estimated 1.7 billion tons annually. Characterized by a highly alkaline pH level ranging between 10.5 and 12.5—primarily due to the addition of sodium hydroxide (NaOH) during processing—red mud presents substantial environmental and handling challenges. The high alkalinity and potential toxicity have traditionally limited its reuse, posing a significant environmental burden.

Despite these challenges, recent research has highlighted the promising potential of red mud in various construction applications, particularly in concrete technology. These studies not only suggest a sustainable pathway for the large-scale utilization of red mud but also indicate that, in certain cases, red mud can enhance specific properties of construction materials. Given these developments, this paper presents a comprehensive review of literature concerning advancements in concrete technology and the innovative reuse of industrial waste—especially red mud—within the construction sector.

Ramaboyana Gangulaiah et al (2021) The examination was directed to study about the properties of cement by utilizing red mud as substitution of bond in cement. The Bayer Process for the generation of alumina from Bauxite metal is described by low vitality effectiveness and it results in the creation of huge measures of residue like, high alkalinity bauxite deposits known as red mud. Presently red mud is created nearly at equivalent mass proportion to metallurgical alumina and is arranged into fixed or unlocked counterfeit impoundments (landfills), prompting significant natural issues. It involves oxides of iron, titanium, aluminum and silica alongside some other minor constituents. Presence of Alumina and Iron oxide in red mud repays the inadequacy of similar parts in limestone which is the essential crude material for concrete generation. Presence of soda in the red mud which when utilized in clinker creation kills the sulfur content in the pet coke that is utilized for consuming clinker enrooted bond generation and adds to the concrete's setting attributes. In view of financial aspects just as ecological related issues, gigantic endeavors have been coordinated worldwide towards red mud the executives issues for example of use, stockpiling and transfer. Various roads of red mud usage are pretty much known however none of them have so far demonstrated to be monetarily reasonable or economically possible. Tests have been led under research facility condition to survey the quality attributes of the aluminum red mud. The undertaking work centers around the appropriateness of red mud acquired for development. Seven test gatherings were established with the substitution rates 0%, 10%, 20%, 30%, 40%, half, 60% of red mud and 5% of hydrated lime with bond in every arrangement in M40 evaluation concrete. To accomplish Pozzolanic property of red mud, hydrated lime was included.

Ahmed Abdelazim Khalifa et al (2021) Red mud (RM), the by-product generated during the alumina extraction process, is considered a valuable secondary raw material, since iron (20–54%) represents its major constituent. Accordingly, the suitability of recycling this RM in the sintering process of Egyptian iron ore was studied. The effect of adding different amounts of RM to the sinter charge mixture (0–10 wt. %) on the sintering process performance as well as the chemical, physical and mechanical properties of the produced sinter was investigated. The results revealed that increasing the amount of red mud in the sinter charge mixture leads to a high improvement in the strength of the produced sinter till reaching a maximum at 7% addition, which deteriorates thereafter. Meanwhile, owing to the fine nature of the red mud, increasing its contents in the sinter charge mixture leads to reduced speed of the sintering process, which consequently affects the productivity at the blast furnace yard. The sinter produced with the addition of 3% red mud shows the highest reducibility. These results indicate the suitability of recycling RM in the Egyptian iron ore sintering process with an amount not higher than 3 wt. % of the total sinter mixture charge.

N.K. Mhaisgawl et al (2021) the purpose of the article was to examine the possibility of using red mud in place of Portland cement in concrete, as well as to assess the strength of a material in compression and cracking tensile tests. Five experimental groups were formed up of 0 percent method for

increasing. With every arrangement of concrete, add 40 percent red dirt and 5 percent hydrated lime. Results showed that Red Mud, when used as a replacement for concrete in the range of 0%, 5%, 10%, 15%, and 20%, may easily mimic the properties of concrete. Red mud and cement should be combined for non-structural construction. From a structural perspective, red mud concrete has potential use in the future.

Rameez Ahmad Mantoo et al (2021) the research paper aim was to investigate the use of red mud in road construction as sub grade. All other necessary properties of the soil sample have been determined in the laboratory such as consistency limits, specific gravity, grain size distribution compaction characteristics and CBR value in accordance with Bureau of Indian standards (BIS) specifications. CBR value is one of the important parameters which indicates the strength of soil sub base of road pavement. Red mud is widely available in Chittorgarh. IRC 37 – 2012 provides guidelines for design of flexible pavements. As per the guidelines, the soil forming the subgrade should have a minimum CBR of 8% for roads having traffic of 450 commercial vehicles per day or higher. From the California bearing ration test of the soil sample is 37.03%, which meet the required specification. So, it was concluded that red mud can be used in road construction as subgrade

Lihua Wang et al (2020) the research paper conducted experiment configuration based on red mud iron tailings, mixed with desulfurization gypsum, lime, cement, activator new cementations materials and analyzed the interaction mechanism of coagulant admixture for iron tailings from red mud separation, and determines the optimal proportion of coagulant admixture through experimental analysis. Then, the whole tailings are used as aggregate and new cementations materials are added to prepare filling materials. The influence of cement sand ratio and mass concentration on the bleeding rate, fluidity and compressive strength of filling materials is analyzed through experimental study. According to the relevant engineering requirements and the analysis of relevant experimental data, the final configuration of paste filling slurry is determined. According to the experimental data, when the mortar ratio is 1:3 and the mass concentration is 68%, the fluidity of the filling slurry is 280mm, the bleeding rate is 2.8%, and the uniaxial compressive strength of 8h is 0.15MPa, 3d The uniaxial compressive strength is 1.9MPa, the uniaxial compressive strength of 7d is 3.0MPa, and the uniaxial compressive strength of 28d is 5.2MPa, which meets the relevant engineering requirements. Through comprehensive consideration, the performance index of the filler slurry is finally determined: mortar ratio 1: 3. The mass concentration is 68%.

Mohammad Slayed Ahmed et al (2020) The Bayer Process for the production of alumina from Bauxite ore is characterized by low energy efficiency and it results in the production of significant amounts of dust-like, high alkalinity bauxite residues known as red mud. Currently red mud is produced almost at equal mass ratio to metallurgical alumina and is disposed into sealed or unsealed artificial impoundments (landfills), leading to important environmental issues. Comprises of oxides of iron, titanium, aluminum and silica along with some other minor constituents. Presence of Alumina and Iron oxide in red mud compensates the deficiency of the same components in limestone which is the primary raw material for cement production. Based on economics as well as environmental related issues, enormous efforts have been directed worldwide towards red mud management issues i.e. of utilization, storage and disposal. Different avenues of red mud utilization are more or less known but none of them have so far proved to be economically viable or commercially feasible. Experiments have been conducted under laboratory condition to assess the strength characteristics of the aluminum red mud. The project work focuses on the suitability of red mud obtained for construction. Five test groups were constituted with the replacement percentages 0%, 5%, 10%, 15%, 20% of red mud and 5% of hydrated lime with cement in each series. To achieve Pozzolanic property of red mud, hydrated lime was added.

Collin G. Joseph et al (2020) research paper reviewed the current efforts made in the utilization of red mud as a valuable industrial by-product, which in turn should minimize its harmful impact on the environment. This detailed review compiles and highlights a variety of novel applications of modified red mud as a coagulant, an adsorbent for wastewater treatment, as well as, its use in catalytic processes and in building materials. The physic-chemical properties of red mud can be tuned by a range of treatment methods including acidification, neutralization and heat treatment. As revealed from the literature reviewed, modifications on red mud for the removal of various types of contaminants have shown promising results. However, further amendment and modifications on red mud are needed to utilize this industrial waste in many other industrial applications. The hydroxides content in red mud make it highly caustic and current disposal practice in landfills creates ecological problems. Red mud has been observed to be a useful by-product for the removal of various types of metal ions, inorganic ions, and dye molecules from wastewater, however, fewer studies have focused on the removal of phenols and other organic water contaminants. It is a well-known fact that the red mud works far superior for pollutants removal if it is first activated with acids, CO2, H2O2 and by calcination at high temperatures. The modifications of unprocessed red mud with strong acids or heat treatment below 700ºC have been found to remarkably enhance the sorption capacities in numerous studies. Among different parameters, pH is an essential factor influencing the sorption process. There are still a few issues that need more consideration, such as improvement of sorption limit through alteration and assessment of sorbent for multi-component pollutants.

Tejaswini et al (2019) the goal of the study was to evaluate the aluminum red mud's strength properties in order to replace some of the cement in concrete. Red mud was substituted for cement in percentages ranging from 0% to 60%, with an internal of 10%, to create the specimens. A 5 percent addition of hydrated lime was made to the mixture to improve its binding abilities. The test results of new properties that are more apt to be submerged in water increase as red dirt content rises. This increase in water use was anticipated since the red mud, which is somewhat lighter in weight, has better particles and more volume, both of which require more water to achieve the same consistency. Red mud's properties are decreased when its content is increased in concrete, yet red mud may still be used in concrete for environmental sustainability. As the content of red mud increases, the carbonation rate decreases. According to these findings, red mud had a stronger corrosion resistance. Red mud is added to concrete to make it resistant to sulphate assault. The red mud replacement's ideal content was 20 percent.

The best method to reduce environmental damage and the constructions industry's carbon footprint may be to utilize red dye in concrete.

P.Ashok et al (2019) The Bayer Process for the production of alumina from Bauxite ore is characterized by low energy efficiency and it results in the production of significant amounts of dust-like, high alkalinity bauxite residues known as red mud. Currently red mud is produced almost at equal mass ratio to metallurgical alumina and is disposed into sealed or unsealed artificial impoundments (landfills), leading to important environmental issues. It comprises of oxides of iron, titanium, aluminum and silica along with some other minor constituents. Presence of Alumina and Iron oxide in red mud compensates the deficiency of the same components in limestone which is the primary raw material for cement production. Presence of soda in the red mud which when used in clinker production neutralizes the sulfur content in the pet coke that is used for burning clinker enrooted cement production and adds to the cement's setting characteristics. Based on economics as well as environmental related issues, enormous efforts have been directed worldwide towards red mud management issues i.e. of utilization, storage and disposal. Different avenues of red mud utilization are more or less known but none of them have so far proved to be economically viable or commercially feasible. Experiments have been conducted under laboratory condition to assess the strength characteristics of the aluminum red mud. The project work focuses on the suitability of red mud obtained for construction. Five test groups were constituted with the replacement percentages 0%, 5%, 10%, 15%, 20% of red mud and 5% of hydrated lime with cement in each series. To achieve Pozzolanic property of red mud, hydrated lime was added. This paper points out another promising direction for the proper utilization of red mud.

Nevin Koshy et al (2019) the research paper explored the use of two untreated industrial wastes, Class-F fly ash and red mud, for synthesizing geopolymeric material at ambient synthesis conditions. The high alkalinity present in the red mud was exploited for the dissolution of silica in the fly ash and red mud. The mechanical, mineralogical, microstructural, and pore characteristics were analyzed and the contributions of curing period, Si/Al, Na/Al, and liquid-to-solid (L/S) ratios on the compressive strength of the end products was investigated. The strength of the end products synthesized under ambient conditions using fly ash and red mud, without the addition of alkali such as NaOH, continues to increase significantly from 7 to 28 days with UCS = 6.19 MPa after 28 days. The stiffness increases with the increase in the curing time and there is a transition from ductile to brittle behavior with the increase in both fly ash content as well as curing time. For the same synthesis conditions, a higher quantity of fly ash with same amount of red mud yields better strength and stiffness values as seen by E = 0.63 GPa at 28 days. The amount of fly ash affects the formation and distribution of various types of pores in the geo-polymeric matrix, wherein a high starting Si/Al ratio gives rise to interstitial pores in the final geo-polymeric matrix. For a curing period of 7 days, the end product showed 6.6 MPa at L/S of 0.35. Results concluded that the unconfined compressive strength of the end products and the L/S ratio follow an inverse exponential relationship similar to the porosity characteristics, and the minimum L/S ratio of 0.35 was found to be optimum for obtaining higher strength fly ash–red mud-based alumina silicates materials with lesser porosity.

Kaliprasanna Sethy et al (2019) the research paper focused on the effective use and suitability of locally available red mud for the partial replacement with cement for various civil engineering constructions. The red mud percentage for replacement of cement was varied from 0% to 20%. Trials mixtures were prepared to obtain target strength of minimum grade of 20 MPa for the control mixture at 28 days. Five different mixtures (RM00, RM05, RM10, RM15 and RM20) were developed to examine the influence of red mud on concrete mechanical properties. The control mixture (RM00) does not contain red mud. In mixtures RM05, RM10, RM15and RM20, cement content was partially replaced with 5%, 10%, 15% and 20% red mud (by weight) respectively. The binder consists of cement and red mud. For each percentage replacement up to 10% the compressive strength values of the red mud concrete showing greater strength value than conventional concrete. But beyond 10% there was reduction in the strength of conventional concrete. Replacement up to 15% the compressive strength values of the red mud concrete coincides with that of conventional concrete. But beyond 10% there is a reduction in the strength value of the concrete. Optimum percentage of the replacement of cement by weight is found to be 10%. By this replacement obtained results were greater than to the results of conventional concrete.

Deepthi Vemuri et al (2018) The Experimental study was conducted to check the properties of concrete by victimization red mud as replacement of cement in concrete. The Empiric method for the assembly of corundum from mineral ore is characterized by low energy potency and it leads to the assembly of great amounts of dust-like, high pH scale mineral residues called red mud. Presence of chemical compound aluminum oxide and Iron oxide in red mud compensates the deficiency of constant parts in limestone that is that the primary material for cement production. Experiments are conducted below laboratory condition to assess the strength characteristics like compressive strength, split tensile strength and flexural strength of concrete and also to know the workability of concrete slump cone test and compaction factor tests are also conducted in this experiment. The replacement percentages are 0%, 5%, 10%, 15%, 20% of red mud with cement in every series in M40 and M50 grade concrete. To realize Pozzolanic property of red mud, hydrated lime was accessorial. In this experiment the comparison of strength characteristics of red mud concrete with and without hydrated lime was studied. The red mud concrete specimens are casted and cured at ambient temperature for 28 days and tested for compressive strength. The optimum value of the compressive strength of red mud concrete was observed at 10% red mud replacement. The compressive strength is more in red mud concrete with hydrated lime compare to red mud concrete without hydrated lime. The project work focuses on the quality of red mud obtained for construction. This paper points out another promising direction for the correct utilization of red mud.

Supriya Kulkarni (2018) the goal of this study is to investigate the use of geo-polymerization of industrial effluents to create a green substitute for concrete mixture. In this work, the physico - mechanical characteristics of geopolymer concrete made from red mud, fly ash, and ground granule blast furnace slag (GGBFS) were investigated. Moisture content, compressive strength, flexural strength, and tensile splitting strength are among the characteristics that have been tested. According to the findings of the experiments, geopolymerization of red mud, fly ash, and GGBFS can be utilized as a sustainable substitute for traditional concrete. Geopolymer concrete was found to have 89.4% the compressive strength of regular concrete. Geopolymer concrete was found to have a modulus of rupture that was 84.26 percent greater than that of regular concrete. Geopolymer concrete was discovered to have a modulus of elasticity that was 81.21 percent greater than that of regular concrete. Geopolymer concrete is shown to absorb more water than traditional concrete. According to the findings, geo-polymerization of industrial effluents can be a good and environmentally friendly substitute for traditional concrete, Hence

Monu Gaur et al (2018) Red mud is a highly alkaline waste by-product generated during the extraction of alumina from bauxite ore using caustic soda. Its disposal poses significant environmental challenges globally. Over the past few decades, extensive research has been conducted to identify cost-effective and sustainable solutions for the utilization of red mud.

This paper presents a comprehensive review of the global utilization of red mud. It summarizes advancements in safe storage practices and explores various approaches adopted worldwide to mitigate the environmental impact of red mud disposal. Annually, a massive volume of red mud is produced, creating a critical ecological concern.

The study provides insights into the production and characteristics of bauxite and red mud, with a specific focus on the global and Indian context. It thoroughly examines red mud disposal and neutralization methods and presents a detailed evaluation of prior research efforts aimed at incorporating red mud into various industrial applications.

The chemical and mineralogical properties of red mud are also discussed, along with associated environmental concerns. The project particularly focuses on replacing cement in concrete with red mud at varying proportions (10%, 20%, and 30%), while maintaining a constant 5% dosage of hydrated lime. Casting was carried out using cube molds (150mm x 150mm x 150mm) and cylindrical molds (150mm x 300mm). Compressive strength was tested at both 7 and 28 days, with promising results observed thus far.

The primary objective of this study is to develop an efficient and practical method for red mud utilization, identify potential areas for improvement, and minimize its environmental impact. By partially replacing cement with red mud, not only is the waste effectively managed, but there is also a potential improvement in the strength and cost-effectiveness of concrete. Additionally, using red mud as a construction material contributes to reduced pollution and diminished environmental hazards, making it a sustainable alternative in the construction industry

Methodology

Collect and analyze peer-reviewed journal articles, conference papers, theses, and government reports related to:

- Chemical and physical properties of red mud.
- Pozzolanic activity of red mud and hydrated lime.
- Past research on cement replacement using red mud.
- Effects on mechanical (compressive, flexural, tensile) and durability properties.

Data Collection and Selection Criteria

- Identify relevant studies based on:
- Red mud replacement percentages (5%, 10%, 15%, etc.).
- Use of hydrated lime as an activator or stabilizer.
- Standardized testing methods (IS, ASTM, EN standards).
- Include experimental studies, comparative analysis, and durability evaluations.

Analysis Framework

Organize the collected data under the following categories:

Material Properties

- Chemical composition (XRF analysis)
- Mineralogical composition (XRD)
- Particle size, specific gravity, and fineness

Fresh Concrete Properties

- Workability (slump test)
- Setting time

Hardened Concrete Properties

- Compressive strength
- Split tensile and flexural strength

- Water absorption and permeability

Durability Characteristics

- Sulphate resistance
- Acid resistance
- Resistance to carbonation and chloride ingress

Comparative Analysis

- Compare red mud-lime mixes with conventional cement mixes.
- Evaluate the influence of different mix proportions on performance.
- Analyze strength gain/loss patterns and setting characteristics.

Environmental and Economic Considerations

- Review the environmental benefits: CO_2 emission reduction, waste utilization.
- Analyze cost implications and practical feasibility of red mud-lime mixes in construction.
-

Conclusion

The review of literature and studies on the use of red mud as a partial replacement of cement, particularly in combination with hydrated lime, reveals promising results from both environmental and engineering perspectives. Red mud, a waste by-product of the alumina industry, poses significant disposal challenges due to its high alkalinity and volume. However, its pozzolanic characteristics, especially when treated or blended with additives like hydrated lime, make it a viable material in sustainable construction practices.

The addition of hydrated lime improves the chemical reactivity of red mud, enhancing the development of calcium silicate hydrates (C-S-H) which contribute to the strength and durability of concrete. Various studies have shown that replacing cement with red mud up to an optimal level (typically 10–30%) can result in acceptable compressive strength, workability, and durability of concrete. Beyond this optimal limit, performance may decrease due to excessive alkalinity or reduced cementations content.

Furthermore, the inclusion of red mud in concrete reduces the environmental impact of cement production by lowering CO_2 emissions and conserving natural resources. It also provides an effective way to recycle industrial waste, promoting circular economy principles in the construction industry.

However, the variability in red mud composition, the need for pre-treatment or activation, and potential long-term durability concerns must be thoroughly addressed through further research and standardization before large-scale application.

In summary, red mud blended with hydrated lime holds significant potential as a partial cement replacement material, offering both environmental benefits and technical feasibility when used within controlled limits.

References

1. Kubilay Kaptan, Sandra Cunha “A Review: Construction and Demolition Waste as a Novel Source for CO_2 Reduction in Portland Cement Production for Concrete” *Sustainability* **2024**, *16*(2), 585; https://doi.org/10.3390/su16020585 Submission received: 3 November 2023 / Revised: 22 December 2023 / Accepted: 24 December 2023 / Published: 9 January 2024
2. Inti sudheer, b.ganesh “experimental studies on concrete utilizing red mud as a partial replacement of cement with hydrated lime” 2023 IJRTI | Volume 8, Issue 9 | ISSN: 2456-3315IJRTI2309031 International Journal for Research Trends and Innovation (www.ijrti.org).
3. Ramaboyana gangulaiah1,khadar mohammed “study on strength parameters of concrete using red mud as a partial replacement of binder content with and without hydrated lime” volume 6 || issue 2 || february 2021 || issn (online) 2456-0774 international journal of advance scientific research and engineering trends impact factor 6.228 www.ijasret.com doi : 10.51319/2456-0774.2021.2.0017.
4. Mohammed Rizwan Raza1 , Ajay Swarup” Experimental Analysis on The EFECT Of Partial Replacement of Cement By Waste Bio Product of Bauxite Residue : A Review” International Journal of Scientific Research in Civil Engineering © 2021 | IJSRCE | Volume 5 | Issue 6 | ISSN : 2456-6667
5. Ahmed Abdelazim Khalifa, Vladimir Yurievich Bazhin, Kuskova Yana Vadimovna, Ahmed Abdelrahim and Yasser Momtaz Zaki Ahmed, [Study the Recycling of Red Mud in Iron Ore Sintering Process], Journal of Ecological Engineering 2021, 22(6), 191–201.
6. Rameez Ahmad Mantoo, Dr. Esar Ahmad and Govind Singh Chauhan, [A Study on Use of Red Mud as Sub-Grade in Road Construction], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 10 Issue 07, July-2021.

7. Lihua Wang , Jie Zhang and Gaochao Sun, [Research and analysis of new paste filling material based on red mud iron tailings], E3S Web of Conferences 198, 01017 (2020).

8. Mohammad Sayyed Ahmed , V. Navya "experimental studies on m40 grade concrete utilizing red mud as a partial replacement of cement with hydrated lime" Vol-6 Issue-1 2020 IJARIIE-ISSN(O)-2395-4396 www.ijariie.com

9. Collin G. Joseph, Yun Hin Taufiq-Yap, Vigneswar Krishnan and Gianluca Li Puma, [Application of modified red mud in environmentally benign applications: A review paper], Environ. Eng. Res. 2020; 25(6): 795-806.

10. Nevin Koshy, Kunga Dondrob, Liming Hu, Qingbo Wen and Jay N. Meegoda, [Mechanical Properties of Geopolymers Synthesized from Fly Ash and Red Mud under Ambient Conditions], Crystals 2019