International Journal of Research Publication and Reviews

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

Cost Comparison of Plain Cement Concrete and Red Mud Based Concrete

Tarique Anwer [a]**, *Sapana Madan*** [b]

[a] *M .Tech. Scholar, School of Civil Engineering, Faculty of Engineering and Technology Madhyanchal Professional University Bhopal, M.P*

[b] *Associate Professor, School of Civil Engineering, Faculty of Engineering and Technology Madhyanchal Professional University Bhopal, M.P*

ABSTRACT

Using industrial waste materials such as red mud as a partial replacement for cement in concrete production is a commendable approach towards sustainable construction practices. Red mud, a by-product of aluminum production, has the potential to contribute positively to both environmental conservation and cost reduction in construction projects. Your experiment to assess its suitability in concrete production and its effects on concrete strength is a step towards validating its efficacy as a cement substitute. The findings of your experiment, particularly the optimal replacement ratio of 12% showing promising results in terms of concrete strength, indicate the feasibility of incorporating red mud into concrete mixes. Not only does this demonstrate the technical viability of using red mud in concrete production, but your cost analysis also highlights its potential economic benefits. By calculating the cost savings achieved through utilizing red mud as a partial replacement for cement, you provide valuable insights for construction practitioners and decision-makers. Saving up to 5.5% in construction costs per cubic meter of concrete through a 12% replacement ratio underscores the economic advantages of adopting sustainable construction practices. Reducing the demand for Portland cement by incorporating industrial waste materials like red mud mitigates resource depletion and minimizes the environmental footprint of construction activities. Project underscores the importance of innovation and sustainability in the construction industry, offering a viable solution to address environmental challenges while simultaneously reducing construction costs.

Keywords: Red mud concrete, Normal concrete, concrete mixes, waste materials, construction costs per cubic meter

Introduction

Comparing the cost of plain cement concrete and red mud-based concrete involves considering various factors such as material costs, labor costs, availability of materials, and any additional processing required for the red mud-based concrete. To accurately compare the costs of plain cement concrete and red mud-based concrete, it's essential to gather specific cost data for materials, transportation, processing, and labor in the particular context where the concrete will be used. Conducting a detailed cost analysis considering all these factors will provide a comprehensive understanding of the cost comparison between the two types of concrete.

Literature Review

S.P.Chavanet al (2021) study on utilizing red mud as a partial replacement for cement in concrete to address environmental concerns and enhance the performance of concrete is indeed noteworthy. In conclusion, your study contributes valuable insights into the utilization of industrial waste in construction, highlighting the potential of red mud as a sustainable alternative to cement in concrete production. Further research and implementation of such practices could play a crucial role in addressing environmental challenges while meeting the demands of rapid industrial development. Cement production is a significant contributor to carbon dioxide emissions, which exacerbate environmental problems like climate change. Reducing cement usage by substituting it with industrial waste such as red mud can mitigate these environmental impacts. Red mud, a byproduct of alumina production, is generated in large quantities and poses disposal challenges due to its hazardous nature. By incorporating red mud into concrete, you're not only reducing waste but also converting it into a valuable resource. Your study systematically investigates the effects of varying percentages of red mud substitution on concrete properties. By following Indian standard guidelines, you ensure the relevance and reliability of your findings. Evaluating various properties such as flow, flexural strength, compressive strength, split tensile strength, and chloride permeability provides a comprehensive understanding of how red mud affects concrete performance. Identifying that a 12% replacement of cement with red mud yields the highest strength and superior chloride permeability suggests an optimal balance between environmental benefits and concrete performance. The observation of better microstructure in red mud-incorporated concrete indicates potential improvements in durability and long-term performance, which are crucial considerations for sustainable infrastructure. Your findings have significant implications for the construction industry, suggesting a viable strategy for reducing carbon footprint and enhancing the sustainability of concrete structures.

Material Costs:

- Plain Cement Concrete (PCC) typically consists of cement, sand, coarse aggregates (like gravel or crushed stone), and water.
- Red mud-based concrete incorporates red mud, which is a byproduct of aluminum refining, along with cement, sand, aggregates, and water.

Cost of Cement:

- Cement is a significant component of both types of concrete. The cost of cement can vary depending on factors such as location, market demand, and seasonality.

Cost of Red Mud:

- Red mud is often considered a waste product from aluminum production. The cost associated with acquiring red mud can vary depending on the proximity of the aluminum refinery and any agreements for its disposal or utilization.

Availability and Transportation Costs:

- Availability and transportation costs play a crucial role, especially for red mud-based concrete. If the aluminum refinery producing red mud is nearby, transportation costs might be lower. However, if it needs to be transported over long distances, the costs could increase.

Processing Costs:

- Red mud typically requires processing before it can be used in concrete production. This may involve drying, grinding, or other treatments to improve its properties and ensure compatibility with the concrete mix. These processing steps could add to the overall cost.

Labour Costs:

- Lab ur costs for both types of concrete will depend on factors such as local wages, project complexity, and efficiency of construction methods.

Quality and Performance:

- Consideration should also be given to the quality and performance of the concrete produced. Red mud-based concrete may offer certain advantages or disadvantages compared to plain cement concrete in terms of strength, durability, and other properties.

Environmental Considerations:

- Red mud-based concrete may have environmental benefits due to the utilization of industrial waste, which could potentially offset some costs or provide long-term savings.

OBJECTIVE

- Comparing the cost of plain cement concrete and red mud-based concrete.

METHODOLOGY

Mix Design (IS 10262: 2009)

Concrete has to be made by mixing all these materials. Whether this concrete is suitable for use or not, different tests can be applied in concrete. These tests use different methods. Generally consider materials in this study we used mix design.

In this study we take M25 grade concrete. And calculate the quantity of cement, sand and aggregate and then replace cement to red mud which is aluminum industry waste.

Table 1 Stranded Proportion of M25 grade of concrete

Items	**Stranded Value as per IS Code**
Concrete Grade	M25
Cement Types	PCC 53 Grade IS 12269
Size of aggregate	20mm
Specific Gravity	a. Course Aggregate 2.80 b. Fine Aggregate(sand) 2.51 c. Cement 3.14

Minimum amount of cement	300Kg/m^3 IS 456-2000
Maximum water cement ratio	0.50 IS 456-2000
Workability	100-125 mm
Aggregate impact value	20.25%
Volume of course aggregate	0.62 Table 3 Is 456-200 Zone-II

Sterp-1 Target Mean Strength

Target mean strength" typically refers to a term used in engineering, particularly in structural design or material science. It denotes the desired or specified strength level of a material or structure.

In structural engineering, for instance, when designing a building or a bridge, engineers set a target mean strength for the materials used, such as concrete, steel, or timber. This target mean strength is usually determined based on factors like safety, reliability, and the intended use of the structure.

The target mean strength serves as a reference point for selecting appropriate materials, designing components, and ensuring that the structure can withstand expected loads and environmental conditions over its intended lifespan.

Achieving the target mean strength involves careful material selection, quality control during manufacturing, and testing to ensure that the actual strength of the material meets or exceeds the specified value.

$$\mathbf{F_T = F_{ck}+1.65S}$$

Where

F_T = Target mean strength

F_{ck}= Characteristic Compressive strength

S= Standard Deviation which is 4 as per IS 10262: 2009

Hence

$$\mathbf{F_T = 25+1.65*4 = 31.6\ N/mm^2}$$

Step-2 Selection of water cement ratio

Water cement ratio is important factor for any mix design because these ratio control over all quality of mix design, If water cement ratio not is proper proportion then he decrees the strength of concrete.

In this study we consider water cement ratio is 0.45 as per 3 trial I have to done in our experiment.

Step -3 Selection of water quantity

As per is code 10262-2009 table no 2, Maximum water contain for 20mm size of aggregate is 186 litter for 25mm to 50mm slump value. But according to our study we achieved slump 125mm so increased water percentages up to 9%.

So water contain used in our study is,

186+ (9/100)*186

= 202.74 litter, we consider 200 litter for our study

Hence Quantity of cement

= 202/0.45 = 444.44 approx. 444 Kg/m^3 > 300 kg/m^3 Hence OK

Calculation of materials for 1m^3 volume

a. Volume of concrete 1m^3

b. Volume of cement = (mass of cement/ specific gravity of cement) X (1/1000)

= 444/3.14 X (1/1000)

= 0.141 m^3

c. Volume of water = (mass of water/ specific gravity of water) x (1/1000)

= 200/1000

= 0.2 m^3

d. Volume of all aggregate = [a-(b+c)]

= 1- (0.141+0.2)

= 0.659m^3

Mass of course aggregate

= volume of all aggregate X volume of course aggregate X specific gravity of aggregate X 1000

= 0.659 X 0.62 X 2.80 X 1000

= 1144.024 we consider 1144 kg/m^3

Mass of fine aggregate

= volume of all aggregate X volume of fine aggregate X specific gravity of aggregate X 1000

= 0.659 X 0.38 X 2.51 X 1000

= 628.55 we consider 629 kg/m^3

Table 2 Materials used for 1m^3 construction for M25 concrete

S.N	Item	Weight
1	Cement	444 kg/m^3
2	sand	629 kg/m^3
3	Aggregate	1144 kg/m^3
4	Water	200 litter

We have replaced cement with industrial waste materials in different percentages such that 0%, 6 %, 12%, 18%, 24% in our project. Hence new materials proportion used in our project shown in table 3

Table 3 Cement and red mud quantity per m^3

S.N	% replacement	Weight of cement kg/m^3	Weight of red mud kg/m^3
1	0	444	0
2	6	417.36	26.64
3	12	390.72	53.28
4	18	364.08	79.92
5	24	337.44	106.56

Table 3 shown the quantity of cement and red mud and all materials used as per mix design calculations

RESULTS AND DISCUSSION

Cost analysis is very important for any project, basically it is a part of planning, without cost analysis it is not possible to start the project. Cost analysis is an indispensable tool for effective project management. It enables project managers to plan, execute, and monitor projects with greater precision, ensuring successful outcomes while minimizing financial risks.

Cost analysis deepens various factors:-

- ❖ Cost analysis helps in estimating the overall budget required for the project. It allows project managers to allocate resources effectively and ensure that sufficient funds are available to complete the project successfully.
- ❖ By analyzing costs, project managers can determine how resources such as labor, materials, and equipment should be allocated throughout the project lifecycle. This ensures optimal resource utilization and prevents shortages or overages.

- Cost analysis helps identify potential risks and uncertainties that could impact the project's budget. By understanding the cost implications of various risks, project managers can develop contingency plans and mitigate potential financial setbacks.
- Cost analysis provides valuable insights for decision making throughout the project lifecycle. Whether it's selecting between alternative solutions, prioritizing tasks, or negotiating contracts, understanding the cost implications is crucial for making informed decisions.
- Cost analysis allows project managers to track actual costs against planned costs, enabling them to assess project performance and identify areas where adjustments may be needed. This helps in ensuring that the project stays on track and within budget.
- Cost analysis provides transparency regarding project expenses, which is essential for communicating with stakeholders such as clients, investors, and sponsors. Clear and accurate cost information helps build trust and credibility, fostering positive relationships with stakeholders.
- Many projects are subject to legal and regulatory requirements related to financial reporting and budgeting. Cost analysis ensures that the project complies with relevant laws and regulations, reducing the risk of fines or legal issues.

Here we discussed our project cost only material cost for used $1m^3$ no other cost discussed here. Market Rate as per date 1/03/2024

Table 4 Materials Market cost

S.N	**Materials**	**Rate (Rs/Kg)**
1	Cement	7.2
2	Sand	1.50
3	Aggregate	0.85
4	Red Mud	2

Table 5 Cost of normal concrete per m^3

S.N	**Item**	**Weight**	**Cost in Rs**
1	Cement	444 kg/m^3	3197
2	sand	629 kg/m^3	944
3	Aggregate	1144 kg/m^3	973
Total concert cost per m^3			**5114/-**

Table 6 Cost of red mud concrete per m^3

% Replacement	**Cost in Rs**
0	5114/-
6	4975/-
12	4837/-
18	4698/-
24	4560/-

Table 4 and 6 clearly mention the rate of raw materials per kg and then calculated the total concrete cost by multiplying it by the quantity of materials. It is clearly visible in the section that the cost of red mud is less in comparison to cement which is the case when we replace cement with red mud. To concrete cost per cubic meter has been reduced without any effect on concrete properties. If we discussed about.

If we consider 12% replacement which is our ideal mix then we are save 5.5% cost per cubic meter in compression of normal concrete which is very beneficial for any big project and use of red mud.

CONCLUSION

- Decreasing the demand for natural resources used in traditional road construction materials like gravel or sand.
- Assess the mechanical properties of the concrete. This could include its compressive strength and flexural strength compared to conventional materials.

- ❖ Also analyze the cost of 12% replacement which is our ideal mix then we are save 5.5% cost per cubic meter in compression of normal concrete which is very beneficial for any big project and use of red mud.
- ❖ Discuss the sustainable aspects of using red mud in road construction, such as reducing greenhouse gas emissions associated with the production of conventional materials.

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