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Original Research Article

Assessing the Impact of Cement Price on the Compressive Strength of M20 Grade Concrete in Nepal

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Abstract

The variability in cement brands significantly influences the compressive strength of concrete, highlighting the need for a cost comparison to evaluate the economic implications of strength variations used for different purposes of buildings and infrastructure, this study was undertaken with the objective to evaluate and compare the compressive strength of M20-grade concrete prepared using various brands of Ordinary Portland Cement (OPC) 43 grade commonly used in the central terai region of Nepal. Additionally, the study aimed to establish a correlation between the cost and strength variations among ten different cement brands available in the market, providing insights into their economic and structural performance. This research provides valuable insights into the impact of various cement brands on the compressive strength of M20 grade concrete used in construction. The evidence-based findings of this study will assist construction professionals and the general public in making informed decisions, ultimately enhancing construction quality and ensuring structural integrity within the region.

Keywords: Cost, Compressive Strength, M20 Concrete, Cement Brands, Co-Relation.

1.0 INTRODUCTION

Concrete is one of the key building materials and the most widely used composite material today. Conventionally, it is a material composed of precisely measured amounts of cement, aggregates, and water that are combined forming a hardened mass used for construction [10]. Also, it is an artificial stone-like material used for various constructional purposes and manufactured by mixing cement and various aggregates [3]. Concrete is a crucial component for many building projects since it is easily molded into any shape and can be customized to a given size and set of features. Because of its superior durability and usefulness, concrete is the most consumed building material on Earth [7]. The quality of concrete materials can have a positive or negative influence on society's well-being [2].

Concrete is a reliable and essential material due to its compressive strength, which ensures remarkable stability and durability. Additionally, its non-combustible nature provides optimal fire protection. Concrete exhibits specific deficiencies, such as an inadequate strength-to-weight ratio, limited ductility, and brittleness. Reinforcement technology addresses these challenges, and as it evolves, its effectiveness in these domains increases, rendering it a crucial construction material [4].

There are many brands of cement available in Nepal—both locally produced and imported. No regular quality control is exercised over the brands. Such differences can create irregularities in the behavior of concrete and can affect the safety and strength of a structure. The majority of cement brands on the market now promise lower-quality concrete and increased risks of structural collapse because of negligent production practices and a lackadaisical regulatory enforcement [3].

It has been known that such physical characteristics of cement as fineness, setting time, chemical composition, and the main compounds' concentrations—tricalcium silicate C_3S and dicalcium silicate C_2S—directly influence the hydration rate and, consecutively, the development of strength in concrete [5]. Although it is well established worldwide how cement affects the strength of concrete, there persists a research gap dealing with the impact that variability among different cement brands has on the performance of concrete in the case of Nepal. Some differences in the performance of various cement brands in Nepal have been noted by research from [11]. However, most have been basic quality tests without relating the differences to specific strength outcomes. Higher levels of C_3S in cement accelerate early strength gain, whereas a higher proportion of C_2S promotes strength development in a slower but more sustained way [9]. Knowing the said factors is very instrumental in the estimation of the influence of cement brand variability on concrete strength.

2.0 MATERIALS AND METHODS

The cement brands used for this research are named as CEMENT-A, B, C, D, E, F, G, H, I, J which are taken from the markets of Central terai region of Nepal. The methodology employed in this study was quantitative, relying predominantly on numerical data. Ten cement brands available in Central terai region of Nepal during the study period were included, ensuring compliance with the relevant Indian Standard specifications. Standardized testing methods were employed for data collection. Each test was conducted multiple times to enhance the reliability of the results, as conclusions based on a single test could not be deemed conclusive. The validity of the study was heavily dependent on the reliability of the data. Compressive strength tests were performed precisely to ensure adherence to established testing norms as followed by the steps shown in Fig.1. All tests were conducted under controlled conditions with uniform curing protocols, minimizing variations caused by external factors. The use of calibrated testing equipment and strict compliance with Indian Standard requirements further contributed to the reliability and consistency of the results obtained. The same quality of fine and coarse aggregates as well as amount of water content are used in experiment as per the quality of cement which satisfies the M20 grade mix design of IS 456-2000.

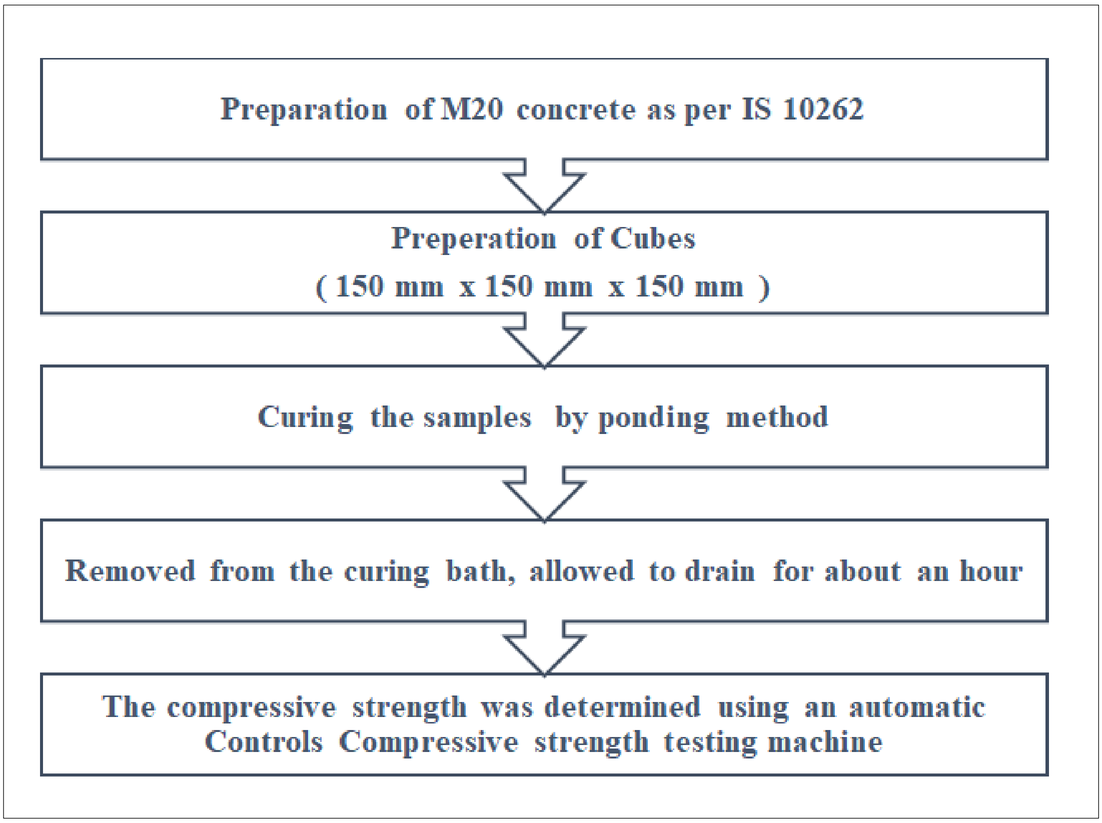

Fig. 1: Experimental design framework

3.0 RESULTS AND DISCUSSION

The findings from the compressive strength test among cement brands, as shown in Fig.2 that there is the importance of selecting appropriate brands for specific construction requirements to ensure structural integrity and durability. For instance, as shown in Fig.2 below the Cement brands such as **Cement-F** and **Cement-C** showed relatively higher compressive strengths, both at 7 and 28 days, making them more suitable for applications requiring greater structural performance. On the other hand, **Cement-A** and **Cement-J** were among the lower-performing brands.

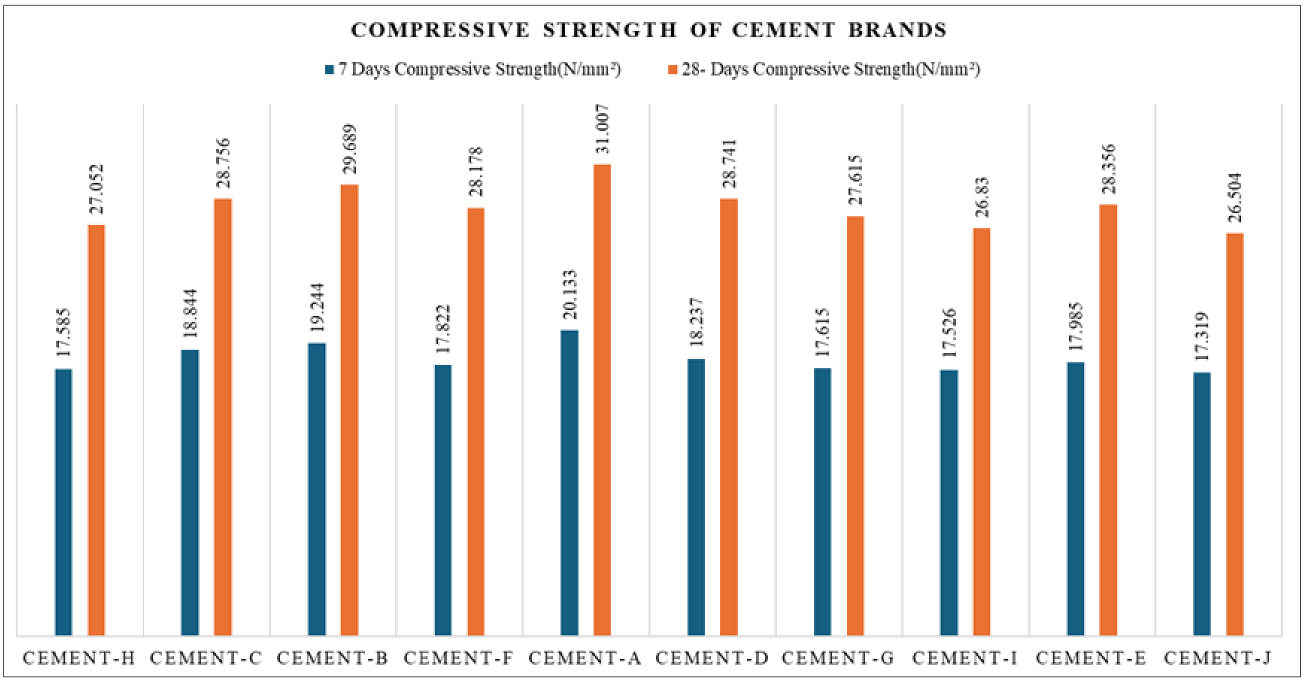

Fig. 2: Compressive strength of different cement brands

A study investigated the compressive strength of concrete in residential buildings in Gaindakot Municipality, Nepal. Ninety cubes from 30 houses in 10 wards were tested, and the average strength was found to be 23.93 N/mm², with 80% of cubes satisfying the National Building Code requirement of 20 N/mm². However, large variations in the proportion of ingredients used showed that the concreting was not consistent. Also, the percentage deviations from the acceptable limit of compressive strength are above 15%, which again indicates that better quality control is needed at the stages of mixing and curing [1-6], analyzed the selection criteria of construction companies in choosing cement by applying the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method to find the best brand of cement for Kathmandu Valley. They found that factors such as pricing, brand recognition, availability, and previous experience are more important than technical specifications. The brands were rated through TOPSIS, though no ranking order was shown. Strength tests showed that a higher price does not mean higher strength. The study concluded that the contractors are considering affordability and accessibility, while clients are concerned about quality and durability [8], researched the effect of different grades of cement on compressive strength by considering sand, crushed granite, stone dust, and cement grades of 33, 43, 53, 43-S, and 53 -S. Having measured the strength of cubic blocks after three, seven, and twenty-eight days of curing, they noted higher compressive strength with increased grades of cement. In the case of grade reduction, on the other hand, it decreases by about 10.81% at seven days and 40.54% at twenty-eight days. *Sarbottam* Cement was tested for six months against popular brands that proved consistent in strength and chemical stability, crossed the compressive strength of brands S, A, and M after 28 days, and achieved a 53-grade level as per Indian standards. Though *Sarbottam* has a few minor problems such as lumps and missing dates, the quality indicates it needs only slight improvements to be more competitive in the market.

The study by [12], in the Central Terai region of Nepal i.e. at Gaindakot Municipality, Nepal emphasizes that both cost and strength are crucial factors in residential building projects. Achieving a balance between cost-efficiency and structural integrity, along with ensuring quality workmanship, is essential for successful construction.

These studies above, highlight critical factors such as material selection, quality control, and the relationship between cement grades and compressive strength is very important, which is aligning with our research findings. Our findings support the notion that balancing cost-effectiveness with quality and durability is crucial for achieving reliable and economically viable concrete structures.

Table 1: 28 days Compressive strength and cost of cement bags

S. N	Cement Brand	28- Days Compressive Strength(N/mm^2)	Average price per bag in Nepalese Rupees
1	Cement-H	27.052	750
2	Cement-C	28.756	810
3	Cement-B	29.689	730
4	Cement-F	28.178	780
5	Cement-A	31.007	800
6	Cement-D	28.741	760
7	Cement-G	27.615	750
8	Cement-I	26.83	700
9	Cement-E	28.356	800
10	Cement-J	26.504	725

Table 1 shows the compressive strength of concrete produced by respective brand of cements and their average price per bag in Nepali market.

To determine whether there is a significant relationship between the cost of cement and its compressive strength a hypothetical test is conducted to find the interrelation between the cost and 28 days compressive strength.

Hypothesis

- **Null Hypothesis (H0)**: There is no linear relationship between the cost of cement and its compressive strength ($r=0$).
- **Alternative Hypothesis (H1)**: There is a linear relationship between the cost of cement and its compressive strength ($r \neq 0$).

Statistical Analysis

1. **Correlation Coefficient (r)**: The calculated value of $r=0.572$ indicates a moderate positive correlation between cost and compressive strength.

2. **t-Test for Significance**:
   - **t-Value**: 1.972
   - **Degrees of Freedom (df)**: $n-2=8$
   - **p-Value**: 0.084 (two-tailed test)

3. **Significance Level (α)**: 0.10

Interpretation

- Since the p-value (0.084) is less than the significance level ($\alpha=0.10$), the null hypothesis (H0) is rejected.
- This indicates that the correlation between the cost of cement and its compressive strength is statistically significant at the 10% level.
- The positive correlation suggests that, as the cost of cement increases, its compressive strength tends to increase as well.

4.0 CONCLUSION

From the above findings in the research, it can be concluded that the different brands of cement available in market satisfies the standards but the cost might be the determining factor of strength. The analysis provides evidence to support the hypothesis that the compressive strength of cement depends on its cost. The moderate positive relationship observed implies that higher-cost cements may generally exhibit greater compressive strength, which could be attributed to variations in material quality or composition.

Conflicts of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

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