

COMPARATIVE STUDY OF CONCRETE COMPRESSIVE STRENGTH USING POTABLE AND RIVER WATER WITH MULTIPLE LINEAR REGRESSION PREDICTION

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ABSTRACT: Concrete strength development depends significantly on water quality, yet in many regions, reliance on potable water (PW) in construction is both unsustainable and costly. This study assesses the viability of river water (RW) as a substitute in concrete mixing and presents a predictive model utilizing Multiple Linear Regression (MLR). Testing was conducted on 36 concrete samples with 3 different mix ratios (1:2:4, 1:1.5:3, and 1:1:2) and water–cement ratios of 0.55, 0.60, and 0.65. The findings indicated that RW attained compressive strength with the 1:2:4 mix at W/C 0.55, satisfying the 15 MPa specification for structural concrete. A two-sample t-test ($p = 0.1147$) indicated no statistically significant difference between RW and PW specimens, confirming RW's potential as an alternative mixing water. The MLR model, developed exclusively from Cavite RW data, demonstrated strong performance ($R^2 = 0.877$, RMSE = 1.57 MPa) and identified cement content and water–cement ratio as dominant strength predictors. While its predictive power is limited to the tested RW source, the framework demonstrates transferability to other contexts through recalibration. This study is novel in bridging empirical RW testing with statistical prediction, offering both sustainability insights and a decision-support tool for concrete mix design.

Keywords: River Water, Concrete, Compressive Strength, Multiple Linear Regression, Sustainable Construction

1. INTRODUCTION

Concrete continues to be the go-to choice for construction, thanks to its impressive strength, adaptability, and cost-effectiveness. Compressive strength serves as an essential measure of a structure's ability to withstand and endure over time [1]. Although many factors, such as mix ratio, aggregate quality, and curing practices, have been extensively researched [2], there has been a growing interest in the impact of water quality, especially from alternative sources, due to increasing environmental and sustainability concerns [3,4].

Clean drinking water has traditionally been considered essential for producing uniform concrete [5], but in many developing regions it is scarce or costly [6], motivating interest in alternatives such as river water [7]. Prior studies report mixed outcomes: chloride and sulfate variations can reduce strength below acceptable levels [8,9], while treated river water has shown comparable 28-day strength to potable water [10]. Although this study focused on pH, river water may also contain contaminants such as chlorides, sulfates, organic matter, or heavy metals that can impair hydration, durability, and reinforcement performance [8,9].

In addition, sustainable alternatives such as recycled fine aggregates [11] and variations in the initial temperature of fresh concrete [12] have also been shown to significantly affect strength development, emphasizing the importance of

considering diverse factors in concrete performance evaluation. These factors were beyond the present scope but warrant broader chemical assessment in future research. Importantly, most investigations remain empirical, relying only on direct strength testing. This highlights the need for approaches that both compare compressive strength using alternative water sources and apply predictive modeling to forecast outcomes.

Min et al. [13] investigated the performance of concrete using various non-potable water sources, including river water, seawater, and even treated wastewater, demonstrating that river water can yield comparable compressive strength to freshwater. However, their approach remained purely empirical. There remains a research gap in the literature: few studies integrate both experimental comparison of potable versus river water and statistical modeling tools to predict concrete strength outcomes. By bridging physical testing with an MLR model trained on river water data, this study introduces a novel framework that not only assesses but also forecasts compressive strength, offering practical insights for future applications. The developed MLR model is based explicitly on the tested river water source, meaning its predictions are most accurate for that dataset. However, the modeling framework provides a transferable approach that can be adapted and validated for other water sources in future research.

This study aims to explore the differences in compressive strength of concrete by using both

potable water and untreated river water collected from Cavite, Philippines, to fill existing gaps in knowledge. Research conducted [14] explored the use of machine learning alongside sensitivity analysis to forecast compressive strength in challenging scenarios like cold joints, highlighting the capabilities of data-driven models in estimating concrete strength. This study utilizes MLR, a simple yet interpretable statistical method, opting for MLR due to its straightforward nature and ease of interpretation in assessing the impact of water source on concrete strength.

Similar to the study of [15], this study presents an MLR model designed to predict the compressive strength of concrete samples made with river water. In addition, Ahammed et al. [16] demonstrated the effectiveness of neural network models for predicting the compressive strength of CFRP-wrapped concrete, highlighting the broader value of predictive approaches in concrete research. This study seeks to explore the potential of river water as a practical alternative to drinking water and to create a predictive model that can be applied in areas with limited resources.

Unlike prior studies that focused solely on empirical testing of river water in concrete, this work uniquely integrates experimental validation with predictive modeling. The novelty of this study lies in combining comparative testing of RW and PW concretes with a Multiple Linear Regression (MLR) model trained on RW data. This dual approach advances the field by providing both immediate experimental evidence and a transferable framework for predictive decision-support in sustainable construction.

2. RECENT LITERATURE AND CONTRIBUTION

In the past three years, research on non-potable water in concrete production has expanded, highlighting both opportunities and limitations for sustainable construction. Min et al. [13] demonstrated that concrete made with river water and other non-potable sources can achieve compressive strengths comparable to potable water when chemical parameters remain within ASTM C1602 limits. Similarly, Hasan et al. [10] showed that river waters from Bangladesh yielded acceptable 28-day strengths, though chloride and sulfate levels required monitoring. More recent work has focused on treated wastewater: Ojo [9] and Belur Raju et al. [17] reported that wastewater can sustain strength but may negatively affect durability if impurities are not controlled. Complementary reviews [7] emphasize that water quality governs both fresh and hardened properties, particularly workability and sulfate resistance. Methodologically, new approaches also include probabilistic acceptance criteria [1] and

predictive modeling through machine learning [14,16], which strengthen reliability compared to purely empirical comparisons.

Despite these advances, most recent studies remain either limited to treated wastewater sources or empirical in nature, without integrating predictive statistical tools for untreated river water. This study advances the state of the art in two ways: (1) it evaluates the compressive strength of concrete using untreated river water from Cavite, Philippines, under controlled mix and water–cement ratios, and (2) it introduces an MLR framework with strong predictive performance. Identifying cement content and water–cement ratio as key determinants. By combining experimental validation with predictive modeling, this study provides a transferable framework for assessing alternative mixing waters, thereby addressing both sustainability and decision-support gaps in the literature.

3. RESEARCH SIGNIFICANCE

This study contributes to the advancement of sustainable construction methods by examining the feasibility of using river water as an alternative to potable water in concrete mixing [17]. It helps engineers and the building sector with insights into optimizing mix designs without compromising structural performance [2]. The findings of this study also contribute to environmental sustainability by promoting the use of local water sources and reducing dependency on processed water. This research lays the groundwork for future inquiries into alternative materials and procedures that enhance concrete strength and long-term durability.

4. MATERIALS AND METHODS

This chapter explains the methods used in a study comparing the strength of Concrete. The study examines the use of drinking water and river water in combination and employs an MLR analysis to investigate the results. The chapter gives a detailed explanation of the research design, experimental procedures, data acquisition techniques, and the creation of the neural network model. The study provides a detailed description of the research methodology and the methods employed.

4.1 Research Design

This study employs an experimental comparative design. The goal is to compare the compressive strength of concrete mixed with potable water versus concrete mixed with river water. This design enables a direct comparison of the two water sources under controlled conditions [18]. The study also incorporates the development of an MLR model for predicting the compressive strength of concrete based

on the water source.

The river water that will be used will come from one of the rivers in Cavite, which is under the Pulunan Bridge in Trece Martires, Cavite. As ASTM C1602 standards about the allowable pH level of water that can be used in mixing concrete, which is 6 to 8.5 [19,20], the river water used contains a pH level of 8, as tested by the DOST Cavite water and wastewater testing laboratory. The following pH level of the river water used in the study is found in Table 1.

Researchers collected the river water in a five-hour timeframe, following the Department of Science and Technology's (DOST) instructions for water quality assessments. This was to make sure that our experimental results were accurate and that we followed the rules for water testing. This time limit is very important for keeping the water sample stable and preventing any big chemical or biological changes that could change the properties of the concrete. They got the water straight from the river in clean containers and then put it into clear plastic bottles. To keep the bottles in the best condition throughout shipping and storage, they were quickly put in an insulated cooler. Each bottle was rinsed with source water, filled with minimal headspace, immediately stored in an insulated cooler (ice packs, target 4–6 °C), and delivered to the DOST Cavite Water and Wastewater Testing Laboratory. Chain-of-custody forms recorded grab time, cooler temperature at dispatch/receipt, and lab receipt time, confirming that all samples arrived within the 5-hour window. pH was analyzed by the receiving laboratory using the SMEWW 4500-H⁺ B electrometric method. This method kept the water at the required temperature and clarity, which are both critical for attaining reliable findings in the experiment. The DOST Cavite laboratory tested the pH of the water samples, and it took three weeks for the results to be given to the researchers.

Table 1. River Water pH Level

pH			
Sample No.	Customer Sample Designation	Sample Description	Method:
			Electrometric SMEWW4500-H*B Date and time of Analysis: February 04, 2025, 10:45 am
CHE-0041	River Water	In Plastic Container approximately. 500 mL in vol.; w/o label clear	8.0 at 25°C

4.2 Data Gathering

As the study progressed to the experimental stage, as seen in Fig. 1 the researchers prepared the concrete specimens using three mix designs. Data collection involves evaluating the compressive strength of two distinct specimen types. In this study, two types of concrete were examined. The first type involved the preparation of concrete using potable water, while the second type involved the use of river water for the same purpose. The researchers prepared samples with different Concrete ratios, specifically 1:2:4, 1:1.5:3, and 1:1:2. Each ratio has a corresponding water-cement ratio of 0.55, 0.60, and 0.65, respectively. Moreover, each specimen consists of three samples, as per ASTM C39, which requires three samples to be made when using a 4x8 concrete cylinder [19].

Potable water specimens were prepared only for the 1:2:4 mix ratio to serve as a baseline for direct comparison with river water. This decision was made to control the scope of the experiment and focus on the most commonly used nominal mix for general concrete works, while dedicating the remaining resources to a more detailed evaluation of river water across multiple mix ratios.



Fig. 1 Mixing of Concrete

Moreover, as part of quality control, slump tests were conducted to assess the workability of the fresh concrete, as shown in Fig. 2. The slump test is one of the most widely used methods for evaluating fresh concrete consistency [21]. The results for both PW and RW mixes fell within the ranges specified by ASTM C143/ACI 211.1 for workable concrete. Lower water–cement ratios produced lower slump values, reflecting reduced workability, while higher ratios yielded slumps approaching medium to high workability thresholds. RW mixes consistently showed slightly lower slump values than PW mixes at equivalent ratios, suggesting a marginal influence of impurities on flow properties. Nonetheless, the measured values confirmed that both PW and RW mixes met the minimum workability requirements for structural concrete applications.



Fig. 2 Slump Tests of Cement

After mixing the concrete according to the specified ratios and verifying its workability through the slump test, the mixture was poured into molds and allowed to set for 24–48 hour, as seen in Fig. 3. Following demolding, the specimens underwent a standard 28-day curing process to achieve optimal strength development. Curing is essential if concrete is to perform the intended function over the design life of the structure while excessive curing time may lead to the escalation of the construction cost of the project and unnecessary delays [22]. In real applications, 28 days are regarded as proper curing time for concrete [23].



Fig. 3 Concrete Specimens

As seen in Fig. 4, the researchers conducted a tests on concrete specimens with a universal testing machine (UTM), adhering to the ASTM C39 guidelines [19]. The river water used for mixing was tested for pH according to ASTM C1602 standards, resulting in pH levels between 6.0 and 8.5 [20]. Research by Hossain [24] highlights the crucial role of water pH in both hydration and the development of strength.

The failure patterns observed in Fig. 4 mostly corresponded to typical types of failure listed in ASTM C39, like cone, cone-and-shear, and columnar cracking. The observed patterns show that the samples were well-compacted and did not include any significant internal voids or segregation. This suggests that the mixing uniformity for both potable

water (PW) and river water (RW) concretes was good. Additionally, there were no consistent changes in failure modes seen between RW and PW specimens; both had similar crack propagation and fracture geometries. This indicates that the utilization of RW did not result in faults or vulnerabilities that would present as unconventional or premature failure mechanisms. The variations in compressive strength between PW and RW mixtures seem to stem mostly from the effects of the water-cement ratio, rather than from differences in how they break. So, the fact that the failure patterns are similar gives more qualitative proof that RW does not change the basic fracture properties of concrete when it meets ASTM C1602 pH standards.



Fig. 4 Compressive Strength Test and Failure Patterns of Specimens

Compressive strength represents one of the most critical mechanical properties in concrete structural design, making its accurate evaluation essential for material and structural engineers [25]. The standard testing procedure involves placing a cured concrete specimen (typically cylindrical or cubical in shape) in a UTM and subjecting it to a continuously increasing axial compressive load until failure occurs. The maximum sustained load at failure is then used to calculate compressive strength by dividing by the specimen's cross-sectional area, providing fundamental data for quality control and structural assessment.

The images above display various failure patterns of concrete specimens subjected to compressive

strength testing. Concrete fractures occur when internal stresses exceed the material's structural capacity, often indicating underlying weaknesses or deterioration. Once a fracture forms, further deterioration will continue to occur [26].

Data collection will involve evaluating the compressive strength of two distinct specimen types. In this study, two types of concrete were examined. The first type involved the preparation of concrete using potable water, while the second type involved the use of river water for the same purpose. The researchers prepared samples with different concrete ratios, specifically 1:2:4, 1:1.5:3, and 1:1:2. Moreover, each specimen will consist of three samples, as per ASTM C39, which requires three samples to be made when using a 4x8 concrete cylinder [19].

4.3 Statistical Treatment

The study employed both inferential and predictive statistical tools to analyze the data gathered for this investigation. A Two-sample t-test was used to see if there was a big difference in the compressive strength of concrete combined with drinking water and river water. The researchers used this test to see if the differences between the means of two separate groups were statistically significant at the 95% confidence level. A p-value of less than 0.05 was thought to be important.

The Researchers used the compressive strength values from concrete combined with river water to create an MLR model for predictive analysis. The dependent variable was compressive strength (MPa), and the independent variables were the amounts of cement, sand, and gravel, as well as the water-cement ratio. The researchers used statistical measures, including R-squared (R^2), Adjusted R-squared, Root Mean Squared Error (RMSE), and the F-statistic p-value, to assess the model's correctness, explanatory power, and importance [27].

4.4 Statistical Analysis

Statistical analysis were performed using MATLAB R2024b (MathWorks Inc.). Independent sample t-tests were conducted to evaluate differences in compressive strength between potable water and river water mixes, while Multiple Linear Regression (MLR) was used to develop predictive models. To assess the consistency of the experimental results, the Coefficient of Variation (CoV) was calculated for each set of specimens. The CoV provides a relative measure of variability (standard deviation divided by the mean) and indicates the uniformity of compressive strength values across replicates. This approach partially addresses statistical reliability in lieu of more advanced assumption tests such as residual normality or multicollinearity diagnostics,

which were beyond the scope of this study.

5. PRESENTATION, ANALYSIS AND INTERPRETATION OF THE DATA

The results of the compressive strength test reveal the variations in concrete strength based on different cement mix ratios, water-cement (W/C) ratios, and the sources of water used, namely river water and potable water. As shown in Table 2 and 3 A total of 36 concrete specimens were examined, consisting of 27 made with river water and 9 crafted with potable water. The mixtures were created using three different design ratios: 1:2:4, 1:1.5:3, and 1:1:2. The researchers tested each mix using three different water-to-cement ratios: 0.55, 0.60, and 0.65. The amounts of sand and coarse aggregate remained the same for every mix ratio.

Table 2. Concrete mixed with River water

Cement Ratio	Water-cement Ratio	Cement	Aggregates	Compressive Strength (MPa)
1:2:4	0.55	0.52	2.17	16.04
1:2:4	0.60	0.52	2.17	11.52
1:2:4	0.65	0.52	2.17	7.02
1:1.5:3	0.55	0.66	2.08	16.84
1:1.5:3	0.60	0.66	2.08	16.35
1:1.5:3	0.65	0.66	2.08	10.83
1:1:2	0.55	0.91	1.90	18.83
1:1:2	0.60	0.91	1.90	17.96
1:1:2	0.65	0.91	1.90	15.85

Table 3. Concrete mixed with Potable water

Cement Ratio	Water-cement Ratio	Cement	Aggregates	Compressive Strength (MPa)
1:2:4	0.55	0.52	2.17	18.22
1:2:4	0.60	0.52	2.17	16.83
1:2:4	0.65	0.52	2.17	15.71

Following a 28-day curing period, we assessed the compressive strength, expressed in megapascals (MPa). The 1:2:4 mix utilizing river water showed a decline in compressive strength, dropping from 16.04 MPa at a 0.55 water-to-cement ratio to 7.20 MPa at a 0.65 ratio. A comparable pattern was noted with drinking water, as the strength decreased from 18.22 MPa to 15.71 MPa.

The mix ratio of 1:1.5:3, which has a higher cement content, demonstrated greater overall strength values, with measurements ranging from 16.84 MPa at a water-cement ratio of 0.55 to 10.83 MPa at a ratio of 0.65. The mix with a ratio of 1:1:2, which had the highest cement content, reached a peak compressive

strength of 18.83 MPa at a water-cement ratio of 0.55. However, as the water content rose to 0.65, the strength decreased to 15.85 MPa. In every instance, an increase in the water-to-cement ratios led to a decrease in compressive strengths [28].

5.1 Comparative Analysis of Compressive Strength

A statistical comparison was done focusing just on the M15 mix ratio (1:2:4), where both water types were employed, to ascertain whether river water can be an acceptable replacement for potable water in concrete manufacturing. The compressive strength data from every group underwent a two-sample t-test using MATLAB to determine whether the noted variations were statistically significant

As shown in Fig. 5, the analysis indicated that concrete produced with river water exhibited a slightly lower average compressive strength compared to that made with potable water, regardless of the water-cement ratios used in the 1:2:4 mix. However, a t-test resulted in a p-value of 0.1147, which exceeds the 0.05 threshold for statistical significance. This suggests that the difference in strength isn't statistically significant and may arise from natural variability or factors related to the experiment.

The t-test is suitable for different group sizes, depending on the assumption of comparably similar variances, as seen by the observed coefficients of variation among replicates. The p-value of 0.1147 indicates that there is no statistically significant difference in compressive strength at the 95% confidence level. But this discovery needs to be regarded as initial evidence instead of a final determination. For further studies, larger and more balanced sample sizes with different mix ratios will be essential to enhance statistical power and support these findings with greater accuracy.

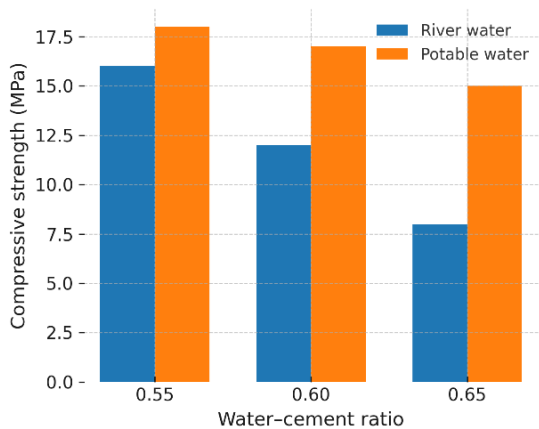


Fig. 5 River vs Potable water bar plot

River water that meets acceptable quality

standards (such as the observed pH of 8.0) can effectively replace potable water in concrete mixing without significantly affecting compressive strength. The comparable performance of RW and PW mixes can be attributed to the fact that, despite possible impurities, the river water satisfied a key ASTM C1602 requirement for mixing water namely, acceptable pH levels. When chlorides, sulfates, and alkalis are present below threshold limits, the cement hydration process is not adversely affected, and the alkaline environment of cement can buffer minor contaminants. This explains why RW specimens achieved strengths similar to PW specimens. From a sustainability perspective, substituting potable water with RW reduces pressure on limited freshwater resources, particularly in areas where drinking water is scarce or expensive. However, further chemical testing and long-term durability evaluation are recommended to fully validate compliance with ASTM C1602 and related standards.

This study evaluated river water primarily on the basis of pH, as pH is a critical acceptance criterion in ASTM C1602 for mixing water. While chlorides, sulfates, alkalis, organic matter, and total dissolved solids are also important determinants of concrete performance, these parameters were excluded from the present scope due to resource constraints. As such, the findings reported here should be viewed as preliminary evidence, limited to short-term compressive strength behavior. Future research is recommended to include full chemical analysis of river water and long-term durability studies in order to comprehensively validate its suitability for structural applications.

5.2 Predictive Modeling Using MLR (River Water Data)

Using 27 river water samples under the three different mix ratios, a MLR model was built to evaluate the predictability of compressive strength for concrete mixed with river water as seen in eq.1. Using four independent variables: cement content (kg), sand (kg), gravel (kg), and water-cement ratio. The model sought to estimate compressive strength.

The final regression model for predicting the compressive strength of concrete mixed with river water is expressed as:

$$\text{Compressive Strength} = 25.731 \cdot X_1 + 0 \cdot X_2 + 15.724 \cdot X_3 - 59.427 \cdot X_4 \quad (1)$$

Where:

$X_1 = \text{Cement (kg)}$

$X_2 = \text{Sand (kg)}$

$X_3 = \text{Gravel (kg)}$

$X_4 = \text{Water - cement ratio}$

The model was developed and evaluated using

MATLAB, and the regression output showed strong statistical performance:

R^2 (coefficient of determination): 0.877

Adjusted R^2 : 0.836

Root Mean Squared Error (RMSE): 1.57 MPa

F-statistic: 21.3, with a p-value = 0.00188

As shown in the fig 6. The regression model demonstrates impressive predictive capabilities [29], as evidenced by a R^2 value of 0.877. This suggests that approximately 88% of the variation in compressive strength can be accounted for by the input variables. Muliauwan, Prayogo, Gaby, and Harsono [30] utilized machine learning techniques, such as artificial neural networks (ANN), regression, and decision trees, to effectively predict compressive strength based on mix design variables. Moreover, the effectiveness of neural network-based approaches, such as the model developed for CFRP-wrapped specimens [16], further supports the potential of predictive frameworks in concrete research. This suggests that the MLR model in this study could also be adapted to evaluate advanced material systems beyond water quality effects.

Linear regression model:

$y \sim 1 + x_1 + x_2 + x_3 + x_4$

Estimated Coefficients:

Variable	Estimate	SE	tStat	pValue
(Intercept)	0	0	-	-
x1	25.731	3.3527	7.6747	0.0015499
x2	0	0	-	-
x3	15.724	3.1597	4.9765	0.0076161
x4	-59.427	12.789	-4.6466	0.0096859

Number of observations: 9, Error degrees of freedom: 6

Root Mean Squared Error: 1.57

R-squared: 0.877, Adjusted R-squared: 0.836

F-statistic vs. constant model: 21.3, p-value = 0.00188

Fig. 6 MLR Output

The adjusted R^2 value of 0.836 indicates that the MLR model explains more than 83% of the variation in compressive strength, which demonstrates strong predictive reliability even with a relatively small dataset. This suggests that the independent variables included in the model, particularly cement content and water-cement ratio, are highly influential in determining strength outcomes. The low RMSE of 1.57 MPa further confirms that the predicted values are very close to the experimentally measured strengths, reflecting good accuracy and minimal error in estimation. Additionally, the F-statistic of 21.3, which is statistically significant at $p < 0.01$, verifies that the model as a whole provides a meaningful improvement over a constant mean model.

These findings align with recent efforts to integrate predictive modeling in concrete research. For example, Cruz et al. [31] applied machine learning to forecast the performance of fly ash-based

concrete, demonstrating that data-driven models can effectively capture the influence of mix parameters on strength. Llanto et al. [14] further employed an ANN with sensitivity analysis to predict the compressive strength of cold-jointed concrete, reinforcing the adaptability of AI-driven frameworks across different concrete conditions. Similarly, this study shows that even with a simple and interpretable approach like MLR, reliable predictions can be achieved for RW-based mixes, provided that model development considers local material conditions and limitations.

Important factors to consider are the amount of cement used and the water-cement ratio. More cement typically boosts strength, whereas a higher water-cement ratio tends to weaken it. These findings resonate with well-established patterns of behavior [32]. This model serves as a valuable resource for predicting the compressive strength of concrete that uses river water. It provides a practical solution for optimizing designs and enhancing construction efficiency, especially in situations where laboratory testing may be scarce or expensive.

The created MLR model is only useful for the experimental ranges and conditions of this investigation. The model was trained exclusively on river water mixtures formulated with three nominal mix classes (1:2:4, 1:1.5:3, and 1:1:2) and water-cement ratios of 0.55, 0.60, and 0.65. The cement concentrations varied between 0.52 and 0.91 (as shown in Tables 2 and 3), with the aggregate gradation kept the same. The response variable was the compressive strength of 4×8 in. cylinders after 28 days. The only source of water was river water from Cavite, which had a pH of 8.0. No further chemical characteristics, including chlorides, sulfates, or total dissolved solids, were investigated. So, the predictions made by the model are only accurate within these ranges and when the materials and curing conditions are identical. To apply the results to other mix proportions, ages, or river water sources with various chemistry, more calibration and validation are needed.

Water-cement ratio affects the compressive strength of concrete mixed with river water. The plot clearly illustrates how these two important factors interact to influence the performance of concrete. The surface elevates along the cement axis, indicating that as the cement content increases, the compressive strength also improves, underscoring the essential role of cement in enhancing building strength through the hydration process, as shown in Fig. 7. On the other hand, the surface slopes downward along the water-cement ratio axis, indicating the anticipated decrease in strength as the ratio rises. The weaker bonding can be attributed to the excess water that dilutes the cement paste. This trend aligns with established mix design principles, confirming that careful control of cement dosage and water-cement ratio is vital for achieving durable and reliable concrete, even when

alternative water sources are used.

The gradient transition from blue, indicating low strength, to yellow, representing high strength, effectively illustrates how well the MLR model captures these relationships. The plot shows that greater compressive strengths are achieved with increased cement content and reduced water-to-cement ratios, as long as the mix remains workable.

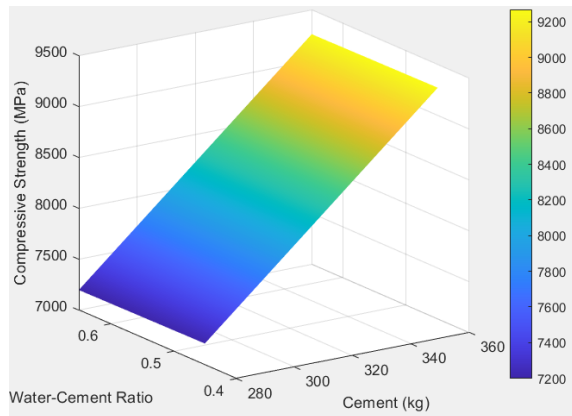


Fig. 7 3D surface plot illustrating the combined effect of cement content and water-cement ratio on compressive strength

The results might not apply to other river systems with distinct chemical compositions because the river water under investigation was taken from a single source in Cavite. With only 3 samples per mix ratio and class, the experimental initiative's length was similarly constrained, which might have hindered the findings' statistical consistency. Moreover, a thorough chemical investigation of chlorides, sulfates, alkalis, and etc. of which might influence hydration and long-term performance, was not included in the assessment of water quality, which was based only on pH measurement. Last but not least, the study ignored durability concerns such as sulfate resistance, chloride attack, and reinforcement corrosion in favor of concentrating on compressive strength at early ages. These limitations point to the necessity of more extensive testing in further studies, including bigger sample numbers, additional river sources, and thorough chemical and durability assessments..

The MLR model shows strong potential as a practical tool for estimating compressive strength where testing resources are limited, helping engineers make quicker mix and quality decisions. Still, its use is limited to the conditions of this study, one river source, small sample size, and pH-only testing, so it should be adapted and validated before wider application.

6. SUMMARY

This study was conducted to compare the

compressive strength of concrete using two water sources, potable water and river water, and to develop a predictive model for concrete made with river water using MLR. A total of 36 concrete specimens were cast and tested: 27 using river water across three mix classes (1:2:4, 1:1.5:3, and 1:1:2) and 9 using potable water under the 1:2:4 mix ratio. Each group was tested under water-cement ratios of 0.55, 0.60, and 0.65. The compressive strengths were recorded after 28 days of curing.

For both water sources, compressive strength decreased as the water-cement ratio increased, confirming expected behavior aligned with Abram's Law.

At the 1:2:4 ratio, concrete mixed with potable water showed higher average strength values than those mixed with river water, but this difference was found to be not statistically significant.

The mix 1:2:4 made with river water reached the minimum strength requirement of 15 MPa at a water-to-cement ratio of 0.55, showing that it can be effectively used for structural applications when conditions are appropriately managed. Nonetheless, the strength values for the 1:1.5:3 and 1:1:2 mixes declined as the water-to-cement ratios increased, and they did not consistently achieve their intended design strength targets.

A t-test conducted on the 1:2:4 results produced a p-value of 0.1147, indicating no significant difference in compressive strength between the two water sources at the 95% confidence level.

The MLR model, built using the 27 river water specimens, achieved strong predictive accuracy with an R^2 value of 0.877, an Adjusted R^2 of 0.836, and an RMSE of 1.57 MPa, indicating a high level of model performance.

Among the predictors, cement content and water-cement ratio had the greatest influence on compressive strength, with cement having a positive correlation and water-cement ratio a negative one.

7. CONCLUSION

The experimental results indicate that RW, with a tested pH of 8.0, is within acceptable parameters for concrete mixing. The average compressive strength of RW-mixed specimens was somewhat lower than that of PW-mixed specimens; however, a two-sample t-test (p-value = 0.1147) indicated that this difference was not statistically significant at the 95% confidence level.

This study found that concrete made with river water using the mix design 1:2:4 successfully reached the minimum compressive strength of 15 MPa with a W/C ratio of 0.55, fulfilling the standard strength requirements for structural use. As the water-cement ratio increased to 0.60 and 0.65, a notable decline in strength occurred, dropping below the necessary threshold.

At the 1:2:4 mix, PW consistently achieved higher compressive strength than RW. At a W/C ratio of 0.55, RW mixes were about 12% lower than PW. At 0.60, the difference increased to 32%, and at 0.65 the gap widened further to 54%, showing that RW mixes are more sensitive to higher water content.

These findings indicate that river water can serve as an alternative mixing water under certain conditions, but performance is influenced by W/C ratio. Importantly, the applicability of these results is limited to RW of comparable quality and pH to that tested in Cavite; other river sources with higher levels of chlorides, sulfates, or organic matter may not yield similar outcomes.

The MLR model was successfully created. The model showed great predicted accuracy with a R^2 value of 0.877 and an RMSE of 1.57 MPa. It also showed that cement content and W/C ratio are the most important determinants for compressive strength.

The MLR model Eq.1 was built for concrete made from RW, and it was quite accurate in predicting compressive strength and statistically significant. Strong performance requirements let the model estimate the strength of concrete precisely and reliably, based on the materials used.

8. RECOMMENDATION

Augment the sample size in subsequent experiments to enhance the statistical strength of the results and incorporate more specific grades and water types for greater applicability.

RW-mixed concrete with higher W/C ratios is more suitable for non-structural works such as blocks, pavements, and curbs, where strength demands are moderate. For structural applications, lower W/C ratios (0.40–0.50) should be explored to reduce porosity, improve hydration, and help offset impurities in RW, enabling higher strength and broader use in construction.

Expand the scope of investigation to include additional chemical parameters (e.g., chlorides, sulfates, organic matter, heavy metals) in future analyses to better assess the suitability of river water in concrete mixing.

Examine additional river water sources from diverse geographic regions to assess the impact of varying chemical compositions, contaminants, and mineral content on concrete performance.

Evaluate sophisticated modeling techniques (e.g., Polynomial Regression, Decision Trees, Neural Networks) in comparison to MLR to ascertain more flexible and superior predictive systems.

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