UTILISATION OF MRA TO PREDICT THE COMPRESSIVE STRENGTH OF CEMENT MORTAR WITH DIFFERENT W/C RATIOS IN THE AREA OF CHEMICAL ATTACK

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Abstract
The non-linear statistical method known as multiple regression analysis (MRA) is used to forecast the strength parameter of mortar or concrete. The versatile substance utilized in building projects is mortar. The w/c ratio, environmental factors, chemicals, etc. all typically affect the cement mortar's compressive strength. There are two phases to the process. Using compressive testing equipment, the mortar's compressive strength was first determined. Different water-cement ratios (0.3, 0.4, 0.5, and 0.6) are used to mould mortar cubes, which are then cured in MgCl2 solutions at 0%, 5%, 10%, and 15% concentrations. The compressive strength of these mortar cubes has been evaluated for 28 days, 56 days, and 90 days. Utilizing experimental results, the prediction equation is developed in the second step. These experimental values and predicted values are compared. R2 and standard error values of modal equation are 0.85 and 2.38 respectively.
Keywords- Multiple Regression Analysis(MRA), W/C ratio.

Introduction

The term "mortar" comes from the Latin word "mortarium," which meaning "to smash." Stones, bricks, and concrete masonry are all bound together by the versatile substance known as mortar. Additionally, it is employed as a decorative element on walls sometimes and to cover in the uneven gaps between stone walls. Cement mortar hardens during curing, resulting in a stiff component. Because it is utilized as the cheapest material to repair the building blocks, the mortar functions as a weaker component in comparison to the building blocks and serves as a sacrifice element in masonry. Mortar typically consists of a binding agent, fine aggregate, and water. In construction cement mortar has better advantage over lime mortar by setting quickly and becoming a rigid mass. The strength of mortar depends upon its mix proportions.

Water-Cement Ratio

If the water content increases strength of cement mortar will decreases. Water-cement ratio is inversely proportional to the compressive strength of the mortar. Approximately 23% of water by the weight of the cement is required to complete the hydration process and 15% of waterby the weight of cement is entrapped in between the voids of cement paste. So, the total water required for consistency of cement is approximately 38% by the weight of the cement.

Regression Analysis

Regression analysis is a statistical process of comparing relationships between outcome results. The most commonly used analysis is linear regression where researcher finds the valuewhich is closest to data according to specific mathematical criterion. Regression analysis is used for two conceptual different purposes. Firstly it is used for divination and predicts whereit is use has most accurate overlap with machine learning. Secondly this analysis can be used to conclude the relationship between independentand dependent variables. But mostly regression compares relationship between dependent variables and collection of independent variables in fixed dataset.

Objectives:

To find the compressive strength of mortar with varying w/c ratio in MgCl2 solution.
To develop the prediction model using experimental compressive strength values with the help of MRA.

Methodology

The study is made by casting of cement mortar cubes (1:3) with varying water-cement from 0.3 to 0.6 and cured in MgCl2 solution(0% to 15%) then tested for 28days, 56days and 90days compressive strength. By using these experimental values compressive strength prediction equation is developed in the regressionanalysis tool. Then these experimental and predicted values are compared.

Materials and their properties:

The following are materials used in project work and each is explained in detail. They are as follows:

i. Cement
ii. Fine aggregate
iii. $MgCl_2$ solution
iv. Water

i. Cement: Cement is a binding material and it occupies 20% to 30% of the total volume of mortar. In this investigation OPC53 grade cementis used.

Table 1: Physical properties of Cement

Physical properties of cement	Results
Standard consistency(%)	33
Initial setting time (minutes)	45
Final setting time(minutes)	187
Fineness modulus(%)	7.5
Soundness(mm)	1.0
Specific gravity	3.15

Fine aggregate: In this experimental investigation naturally occurring river sand is used. The sand which is passing through the 4.75mm sieve and retained on 75µ sieve is used. Sand is of zone-II as per IS 383-1970. In the mortar 70%to80% of volume occupies by the fine aggregate.

Table 2:Physical properties of Fine aggregate

Description of test	Results
Specific gravity	2.71
Water absorption	1.42
Fineness modulus	2.39
Zone	ii

$MgCl_2$ solution: It is prepared by adding the magnesium chloride pellets to the distilled water. For example to prepare the 5% $MgCl_2$ solution 5grams of magnesium chloride pellets are added to 1 litre of distilled water.

Water: As per IS 456: 2000 the water used in the mixing should be portable water. Water is clean, odorless, colorless and free from organics material. Water which is used in mortar mixing having ph range from 6.5 to 8.5.

Table 3: Quantity of materials per cubic meter fordifferent w/c ratio

w/c ratio	Cement(kg/m^3)	Sand(kg/m^3)	Water(lit $/m^3$)
0.3	478.8	1915.2	143.64
0.4	478.8	1915.2	191.52
0.5	478.8	1915.2	239.4
0.6	478.8	1915.2	287.28

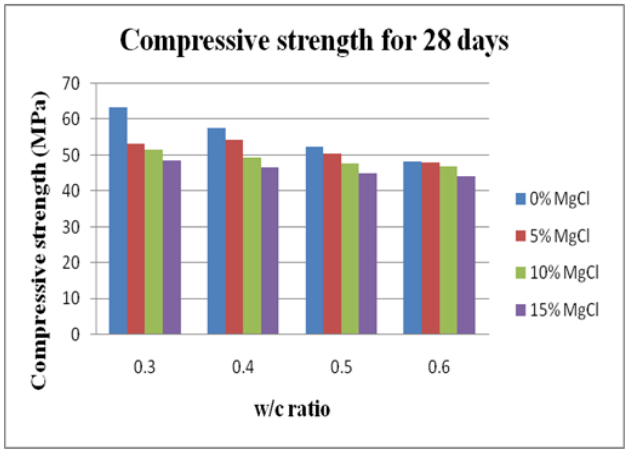
Figure 1: Casting of cement mortar cubes

IS 4031(part 6) 1988 code book is followed to cast the mortar cubes.

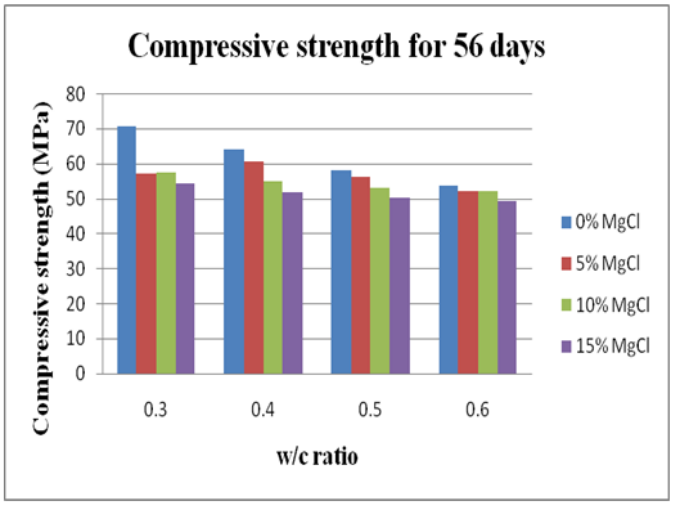
Results

Compressive Strength Test

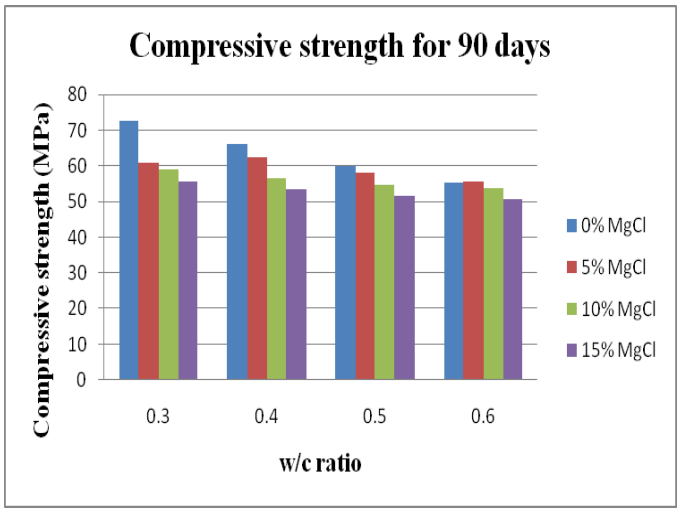
In the below graphs, w/c ratio is taken on x-axis and compressive strength is taken on y-axis. Three graphs are plotted for 28days, 56days and 90days curing age. From all the graphs it is concluded that the maximum compressive strength is obtained at 0% $MgCl_2$ solution and
0.3 w/c ratio.



Graph 1: Compressive strength for 28 days



Graph 2: Compressive strength for 56 days



Graph 3: Compressive strength for 90 days

Development of Modal Equation

The multiple linear regression is developed usingexcel software and the modal accuracy is found out in terms of R^2as 0.85. This R^2 value shows that strong relation between the predicted values and experimental values.

Compressive Strength = Intercept+(W/Cratio)*a1+(Curing days)*a2+($MgCl_2$ %)*a3 Finally obtained equation is:

Compressive Strength= 65.28 – 26.99(W/Cratio) + 0.11(Curing days) – 0.65($MgCl_2$ %)

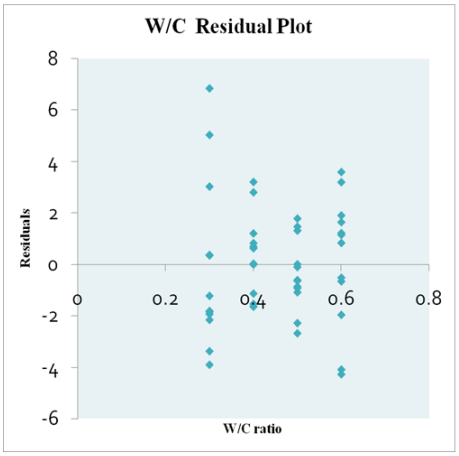
Output:

Regression statistics:

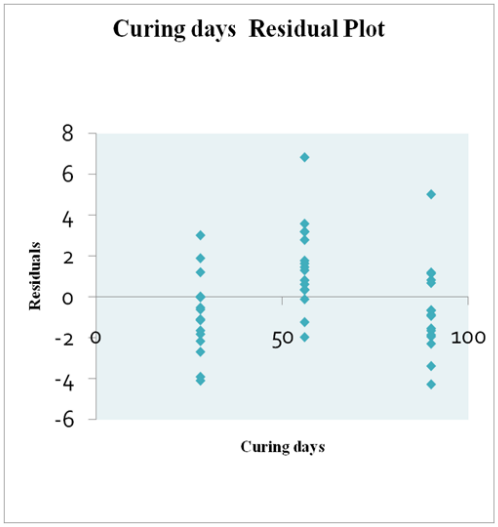
Mutliple R	0.925582
R Square	0.856702
Adjusted R Square	0.846932
Standard Error	2.387539
Observations	48

Plotting

The below graphs are plotted between dependentvariable (residuals) and independent variables (w/c ratio, curing days). Residual showing on Y- axis and independent variables on X-axis. Residual is the difference between the predicted values and experimental values.

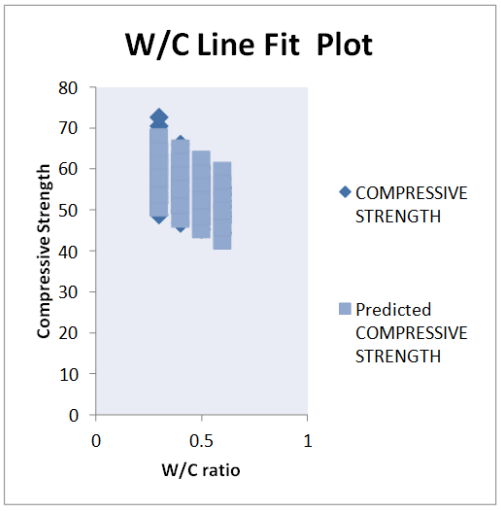


Graph 4: Residuals Vs W/C ratio

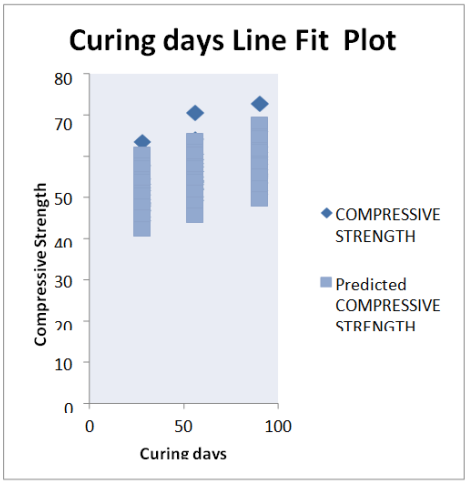


Graph 5: Residuals Vs curing days

Plotting for compress ive Strength:



Graph 6: Compressive strength Vs W/C ratio



Graph 7: Compressive strength Vs curing days

Conclusions

The conclusions from the study are as follows: The compressive strength of cement mortar decreases from 0.3 to 0.6 when the w/c ratio is increased. The compressive strength of the mortar is lowered from 0 to 15 by increasing the MgCl2 solution %. With a 0.3 w/c ratio and a 0% MgCl2 solution, the compressive strength is at its maximum. Minimum strength using 15% MgCl2 solution and 0.6 w/c. The R2value for the linear regression model, which was created, was 0.85. The model's standard error is 2.38, which is quite low.

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