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# PREDICTION OF STRENGTH PROPERTIES OF SELF CURING CONCRETE BY REGRESSION ANALYSIS

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## ABSTRACT

For achievement of strength to concrete curing process performs crucial role. Nowadays infrastructure development is not possible without concrete. In region where scarcity of water there is problem of curing with water and it affects strength and durability of concrete. Therefore, in present investigation natural and chemical admixtures were added in concrete which helps to cure concrete without external water. Curing admixture such as Polyethylene glycol 400 [PEG 400] and wood powder [WP] used in percentage of 1%, 1.5%, 2% and 6%, 7%, 8% respectively. It was observed that concrete achieves considerable strength for combination of 1.5% PEG400 and 8% wood powder. The experimental outcomes are validated with regression techniques. Strength of concrete predicted by regression equations which helps to reduce time and money for preparation of concrete.

## INTRODUCTION

Curing is the process of maintaining the correct moisture content, especially for 28 days, to promote optimal hydration of the cement immediately after application. Hardening plays an important role in the formation of concrete microstructure and pore structure. Self-hardening concrete means that the concrete does not need external curing. R. V. V. Raj 2024 (1) studied that curing is the name given to methods used to promote cement hydration by controlling the movement of temperature and moisture from and to the concrete. A.M. Saboon et al. 2018 (2) reviewed that for good performance and durability of concrete, curing is essential. Conventional curing also called external curing and internal curing is often referred to as self-curing concrete. Self-curing provides additional moisture in concrete for having good performance and durability. By comparing with conventional concrete, the self-curing concrete reduces the water evaporation from concrete and increase the retention capacity of concrete and also it prevents early age cracking. M. F. M. Zain et al. 2002 (3) investigated regression models formulated for each condition indicated that the strength development was dependent on methods of curing. Compressive strength of concrete depends on the medium in which these specimens were cured and there exist a positive correlation between the compressive strength of concrete and curing age. S. S. Kadam et al. 2020(6) and S. A. Rajkunakaran et al. 2022(7) predicted strength properties of steel fibre reinforced concrete in which fibres were reinforced at different location in concrete.

**MATERIALS:**

1. Cement: Ordinary Portland Cement of 53 grade (Ultratech cement) confirming to IS 4031-1988 used for the experimental work. Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminium, iron and other ingredients. Portland Pozzolana Cement (PPC) is a blended cement produced by grinding Ordinary Portland Cement (OPC) clinker with pozzolanic materials (such as fly ash, volcanic ash, or calcined clay) and gypsum.
2. Polyethylene glycol (PEG- 400): Polyethylene glycol is a polyether compound with many applications from industrial manufacturing to medicine. PEG is also known as polyethylene oxide (PEO) or poly oxy ethylene (POE), depending on its molecular weight. The structure of PEG is

commonly expressed as H-(O-$CH_2$-$CH_2$)n OH by A Joshi et al. 2023(4) and G Sudrashan et al. (2021) (5).

3. Wood powder: Wood powder is a byproduct from furniture and lumber mills. In a mosquito coil, it is compressed to create the structure of the coil, which is then infused with the active ingredient.
4. Coarse Aggregate: Coarse aggregate is a granular material like sand, gravel, or crushed stone that is used to make concrete. It is usually naturally occurring and can be obtained by blasting quarries or crushing them by hand or crushers. In present work most of the crushed coarse aggregate of size passing through 16.5 mm sieve and retained on 10mm sieve were used. The specific gravity of coarse aggregate is 2.8, impact value and bulk density is 15.20 % and 1657 Kg/$m^3$ respectively.

**PREPARATION OF MIX:**

In this work, it was proposed to study the effect of polyethylene glycol 400 (PEG 400) and wood powder on strength characteristics of self-curing concrete by adding PEG by weight of cement for M20 grade of concrete.

MIX DESIGN: Mix design was carried out as per IS code 10262-2009. The proportion of different ingredients of concrete is as shown in TABLE below TABLE 1.

TABLE No.1: Quantity of ingredients of M20 concrete.

| Fine aggregate (Kg) | Coarse aggregate (Kg) | Water (Lit.) | Cement (kg) |
|---|---|---|---|
| 748 | 1547 | 197 | 394 |

RESULTS AND DISCUSSION:

1. Compressive strength test:

TABLE No.2: Average compressive strength for different percentage of PEG.

| Sr. no. | Percentage of PEG | Ave. Compressive strength in N/$mm^2$ |
|---|---|---|
| 1 | 1 | 29.33 |
| 2 | 1.5 | 31.33 |
| 3 | 2.0 | 32.20 |

TABLE 2 shows average compressive strength of different percentage of PEG.

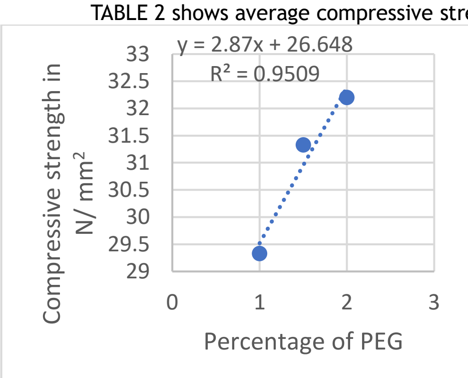


FIGURE 1: Correlation between compressive strength and wood powder

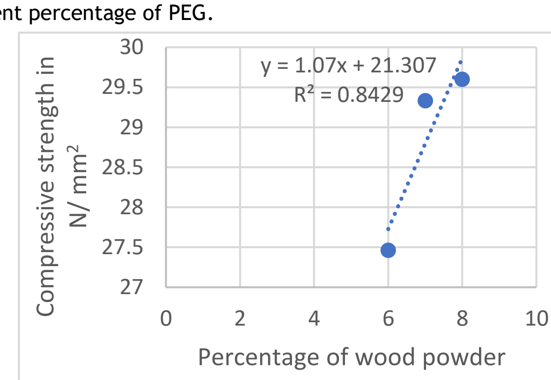


FIGURE 2: Correlation between compressive strength and Percentage of PEG.

Linear regression model was developed by M. F. M. Zain et al. 2008 (8) and Faeze Khademi et al. 2016 (9) to predict strength properties of concrete. The strength of correlation between PEG and wood powder with compressive strength is 0.80 and 0.87 respectively as shown in figure FIGURE 1 and 2. It shows strong correlation between two variables. The adjusted R square value is 0.84 in regression statics table shows that 84% of change in compressive strength is explained by predictor variable that is percentage of PEG 400. The f value of independent variable is 0.03 is less than 0.05. It indicates that confidence level of proposed model is greater than 95 percentage. The P value as shown in the TABLE 5, is 0.03 which is less than 0.05.

TABLE No.3: Average compressive strength for different percentage of wood powder.

| Sr. no. | Percentage of wood powder | Ave. Compressive strength N/$mm^2$ |
|---|---|---|
| 1 | 6 | 27.46 |
| 2 | 7 | 29.33 |
| 3 | 8 | 29.17 |

TABLE 3 shows average compressive strength for different percentage of wood powder in self-curing concrete. It acts as an admixture to enhance curing properties of concrete.

TABLE 4. Regression statics for Compressive strength test results with PEG 400

| Regression Statistics | |
|---|---|
| Multiple R | 0.98 |
| R Square | 0.95 |
| Adjusted R Square | 0.84 |
| Standard Error | 0.58 |

TABLE no 4 shows regression statics where R square value is 0.95. It indicates that good ness of fit of regression model with experimental values.

TABLE 5. Significance F for Compressive strength test results with PEG 400.

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Regression | 3 | 4.11845 | 1.372817 | 19.3521 | 0.03 |
| Residual | 1 | 0.212817 | 0.212817 | | |
| Total | 4 | 4.331267 | | | |

TABLE 5 shows significance f value is 0.03, which is less than 0.05 it indicates confidence level of model is greater than 95 percentage.

TABLE 6. P-value for Compressive strength test results with PEG 400

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 26.64833333 | 1.014206 | 26.27507 | 0.004217 |
| X Variable | 2.87 | 0.652406 | 4.399102 | 0.032298 |

TABLE 6 shows p value of the regression model.

The regression equation based on the regression model is as follows:

y = 2.87x + 26.648 ------------------------------------ equation 1

Equation 1 shows regression model between compressive strength as dependent variable and PEG 400 as independent variable.

TABLE 7. Comparison of compressive strength by experimental and regression method with PEG.

| Sr. no. | Percentage of PEG | Ave. Compressive strength by experiment $N/mm^2$ | Regression |
|---|---|---|---|
| 1 | 1 | 29.33 | 29.51 |
| 2 | 1.5 | 31.33 | 30.95 |
| 3 | 2.0 | 32.20 | 32.68 |

TABLE 7 shows comparison of compressive strength by experimental and regression method with PEG.

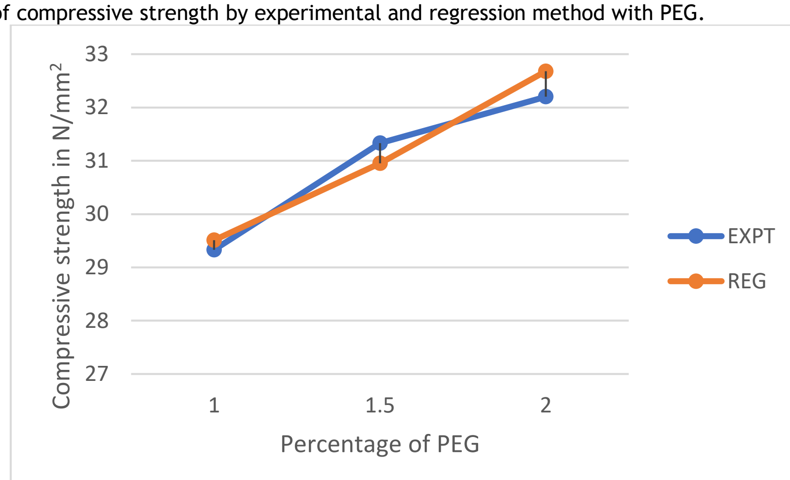


FIGURE 3: Fitted line equation curve for compressive strength test result with PEG

TABLE 8. Regression statics for Compressive strength test results with wood powder.

| Regression Statistics | |
|---|---|
| Multiple R | 0.824852658 |
| R Square | 0.680381907 |
| Adjusted R Square | -3 |
| Standard Error | 0.82874403 |
| Observations | 1 |

TABLE 8 shows Regression statics for Compressive strength test results with wood powder.

TABLE 9. Significance F for Compressive strength test results with wood powder.

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 3 | 1.46205 | 0.48735 | 2.128734 | 0.004 |
| Residual | 1 | 0.686817 | 0.686817 | | |
| Total | 4 | 2.148867 | | | |

TABLE 9 shows Significance F for Compressive strength test results with wood powder.

TABLE 10. P-value for Compressive strength test results with wood powder

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 22.66833333 | 4.129885 | 5.488854 | 0.114726 | 29.8068266 | 75.14349 | 29.8068 | 75.14349 |
| X Variable 1 | 0.855 | 0.586011 | 1.459018 | 0.382516 | 6.59096969 | 8.30097 | 6.59097 | 8.30097 |

TABLE 10 shows P-value for Compressive strength test results with wood powder

y = 0.855x + 22.66 -------------------------------------------------- 2

Equation 2 shows regression model between compressive strength as dependent variable and wood powder as independent variable.

TABLE 11. Comparison of compressive strength by experimental and regression method with wood powder.

| Sr. no. | Percentage of wood powder | Ave. Compressive strength by experiment N/mm$^2$ | Regression |
|---|---|---|---|
| 1 | 6 | 27.46 | 27.79 |
| 2 | 7 | 29.33 | 28.64 |
| 3 | 8 | 29.17 | 29.50 |

TABLE 11 shows comparison of compressive strength by experimental and regression method with wood powder.

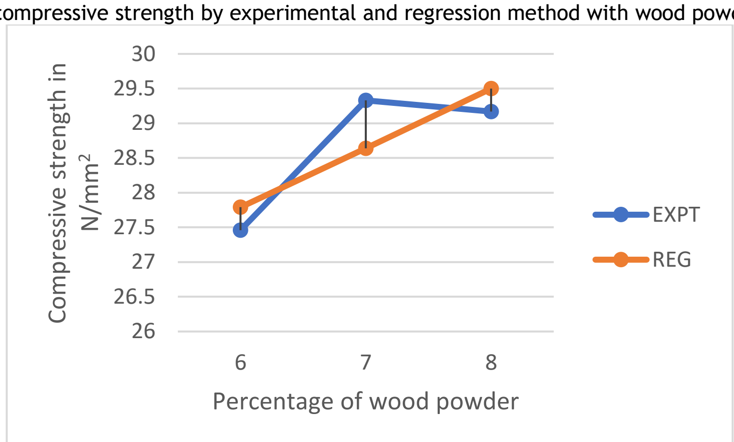


FIGURE 4: Fitted line equation curve for compressive strength test result with wood powder.

2. Flexural strength test:

TABLE 12: Average flexural strength for different percentage of PEG

| Sr. no. | Percentage of PEG | Ave. flexural strength in N/mm$^2$ |
|---|---|---|
| 1 | 1 | 3.25 |
| 2 | 1.5 | 3.80 |
| 3 | 2.0 | 3.13 |

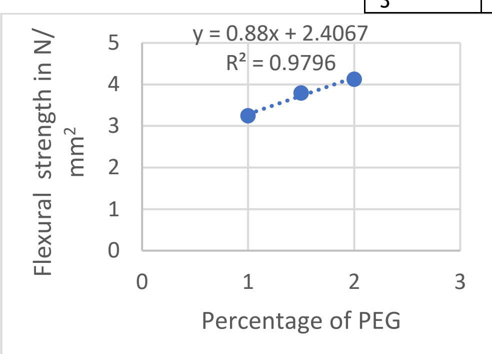


FIGURE 5: Correlation between flexural strength and Percentage of PEG.

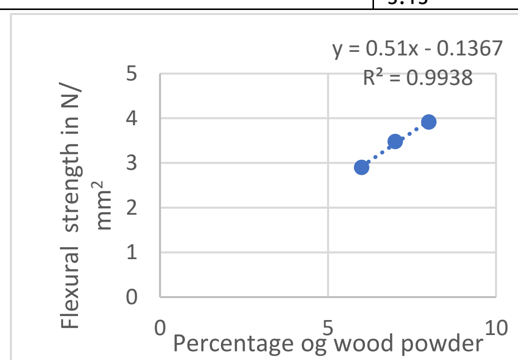


FIGURE 6: Correlation between flexural strength and wood powder

The strength of correlation between PEG and wood powder with flexural strength is 0.64 and 0.81 respectively. It shows strong correlation between two variables. The adjusted R square value is 0.87 in regression statics TABLE shows that 97 % change in flexural strength is explained by predictor variable that is percentage of wood powder. The P value of independent variable is 0.03 is less than 0.05. It indicates that confidence level is greater than 95 percentage

TABLE 13. Average flexural strength of concrete of different percentage of wood powder

| Sr. no. | Percentage of wood powder | Ave. flexural strength in N/mm$^2$ |
|---|---|---|
| 1 | 6 | 2.9 |
| 2 | 7 | 3.48 |
| 3 | 8 | 3.92 |

TABLE 13 shows average flexural strength of concrete of different percentage of wood powder.

TABLE 14. Regression statics for flexural strength test results with PEG 400

| Regression Statistics | |
|---|---|
| Multiple R | 0.989743 |
| R Square | 0.979592 |
| Adjusted R Square | -3 |
| Standard Error | 0.089815 |
| Observations | 1 |

TABLE 14 shows regression statics where R square value is 0.97. It indicates that good ness of fit of regression model with experimental values.

TABLE 15. Significance f value for flexural strength test results with PEG 400

| | *df* | *SS* | *MS* | *F* | Significance F |
|---|---|---|---|---|---|
| Regression | 3 | 0.3872 | 0.129067 | 48 | 0.001 |
| Residual | 1 | 0.008067 | 0.008067 | | |
| Total | 4 | 0.395267 | | | |

TABLE 15 shows significance f value is 0.001, which is less than 0.05 it indicates confidence level of model is greater than 98 percentage.

TABLE 16. P-value for flexural strength test results with PEG 400

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | 2.406667 | 0.197456 | 12.18837 | 0.052115 | 0.10225 | 4.915584 | 0.10225 | 4.915584 |
| X Variable 1 | 0.88 | 0.127017 | 6.928203 | 0.091258 | -0.7339 | 2.493905 | -0.7339 | 2.493905 |

TABLE 16 shows P-value for flexural strength test results with PEG.
y = 0.88x + 2.406 -------------------------------------------- equation 3

Equation 3 shows regression model between flexural strength as dependent variable and PEG 400 as independent variable.

TABLE 17: Comparison of flexural strength by experimental and regression method with PEG.

| Sr. no. | Percentage of PEG | Ave. Flexural strength in $N/mm^2$ | Regression |
|---|---|---|---|
| 1 | 1 | 3.25 | 3.28 |
| 2 | 1.5 | 3.80 | 3.72 |
| 3 | 2.0 | 3.13 | 4.16 |

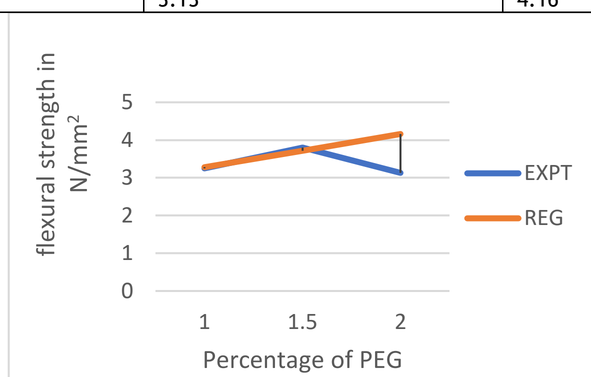


FIGURE 7: Fitted line equation curve for flexural strength test result with PEG.

TABLE 18. Regression statics flexural strength test results with wood powder

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.996875 |
| R Square | 0.99376 |
| Adjusted R Square | -3 |
| Standard Error | 0.057155 |
| Observations | 1 |

TABLE 19: Significance f value for flexural strength test results with wood powder

| | *df* | *SS* | *MS* | *F* | Significance F |
|---|---|---|---|---|---|
| Regression | 3 | 0.5202 | 0.1734 | 159.2449 | 0.004 |
| Residual | 1 | 0.003267 | 0.003267 | | |
| Total | 4 | 0.523467 | | | |

TABLE 20: P Value for flexural strength test results with wood powder

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* | *Lower 95%* | *Upper 95%* | *Lower 95.0%* | *Upper 95.0%* |
|---|---|---|---|---|---|---|---|---|
| Intercept | -0.136 | 0.28482 | 0.47984 | 0.715185 | 3.75564 | 3.48231 | -3.75564 | 3.48231 |
| X Variable 1 | 0.51 | 0.040415 | 12.6192 | 0.050343 | 0.00352 | 1.0235 | -0.00352 | 1.023515 |

Y=0.51X+0.13----------------------------------------- equation 4
Equation 3 shows regression model between flexural strength as dependent variable and wood powder as independent variable.

TABLE 21: Comparison of flexural strength by experimental and regression method with wood powder.

| Sr. no. | Percentage of wood powder | Ave. Flexural strength by experiment in N/mm$^2$ | Regression |
|---|---|---|---|
| 1 | 6 | 2.9 | 3.19 |
| 2 | 7 | 3.48 | 3.70 |
| 3 | 8 | 3.92 | 4.21 |


FIGURE 8: Fitted line equation curve for flexural strength test result with wood powder.

## CONCLUSION

For regression model as explained above the coefficient of correlation values for cube compressive strength and flexural strength is 0.80, 0.87, 0.64 and 0.81 which indicates that regression model is best suited for experimental investigation.

1. The experimental outcomes related with results obtained from regression techniques and found to be endurable.
2. For the prediction of strength properties such as compressive strength and flexural strength regression tool could be effectively and efficiently utilized.

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