# Evaluation Of Compressive Strength On Red Mud Concrete By Using Ultra Pulse Velocity

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## Abstract

This study supports the use of ultrasonic pulse velocity technique for non-destructive testing on concrete. The cement in the M30 grade of concrete is substituted with red mud in percentages such as (5%, 10%, 15%, 20%, 25% and 30%) with a ratio of (1:2.0:3.54) and a water cement ratio of (0.45) for the curing period of 7 and 28 days.The correlation between compression strength and UPV values is determined using regression analysis. The results shows that the values are respectively, 2.52% and 3.52% greater than normal compressive strength. The construction industry will be able to utilize waste red mud as a challenging building material according to this research.



**Keywords:** Compressive Strength, Non Destructive Test, Red Mud, Regression Analysis, Ultrasonic Pulse Velocity.

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## INTRODUCTION

Red mud is a combination of substances that were initially found in the parent mineral and substances generated during the Bayer process. Red mud disposal is difficult; it must be done either toward the land or into the nearby sea or ocean everywhere in the world. Red mud disposal is problematic because it creates a surface that, even after drying, cannot be designed on or framed. The surrounding area's water, land, and air are all negatively impacted by its high pH scale. Therefore, the disposal of minerals presents a terrible environmental problem. The red mud with high quality that is produced for the assembly of alumina is the most significant outcome of the environmental concern for the alumina sector.

The development of a nation's economy depends heavily on the manufacture of cement. Large cement plants have had a difficult time starting up in recent years despite the fact that there is a significant increase in demand for cement and a long gestation period. In order to make concrete more environmentally friendly, it is currently popular throughout the world to use both treated and untreated industrial waste as a raw material. Red mud is used to produce cement, which not only uses less energy but also has better early strength and durability qualities.

Non-destructive tests are those that do not affect the quality of the concrete when used on it. A test is described to as "non destructive" if it doesn't damage the building or affect it in any other ways that the client finds acceptable The ultrasonic pulse velocity method is the quickest, easiest, and least expensive to utilise. In this investigation, specimens were subjected to the ultra pulse velocity test after 7 and 28 days of curing, and the findings of the UPV test were compared with those of traditional cube testing. In order to improve prediction accuracy and validation quality, the relationship between compressive strength and UPV was studied using regression analysis.

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## MATERIALS USED

Materials utilised for this experiment included Ordinary Portland Cement (OPC) with a specific gravity of 3.15 that conforms with IS: 12269-1987. According to IS 383-1970, coarse aggregate (20 mm down size, specific gravity 2.734) and fine aggregate (zone II, specific gravity 2.53) are used. Red mud from the Hindalco Steel Industry was brought in and used to replace cement. It has a specific gravity of 2.93. It was produced utilizing Bayer's process for generating alumina from bauxite ore. The water utilised in the mix design was portable drinking water that met the requirements of IS 456-2000.

## METHODOLOGY

### 3.1-Compressive Strength Test

Cubes with the dimensions 150x150x150mm were casted for the investigation. According to IS 10262-2009, the mix design for M30 grade was prepared (1:2.00:3.54). Later, water was added and properly mixed with a W/C of 0.45. Concrete was manually compacted after it had been poured into the moulds. The cubes were left for 24 hours, after which the moulds were taken apart and the cubes were placed in a curing tank to cure. In conformance with IS 516-1959, testing was concluded after seven and twenty-eight days.

### 3.2-Ultra Pulse Velocity Test

Based on the pulse velocity method, ultra plus velocity testing of concrete can reveal information about cavities, cracks, faults, and concrete homogeneity. The apparatus should use pulses to transmit through concrete, receive pulses that have been amplified, and measure the time it takes for a pulse to arrive at a receiver. In accordance with IS: 13311 (part1)-1992, concrete cubes were casted and cured for 7 and 28 days, and then subjected to ultra pulse velocity.

## RESULTS AND DISCUSSION

**Table 1.** Test results of UPV and compressive strength on concrete after 7 days

| Red mud Replacement in (%) | Velocity (km/sec) | Compressive Strength N/mm² | Concrete quality as per IS 13311(part – 1) : 1992 |
|---|---|---|---|
| 0 | 4.10 | 24.96 | Good |
| 5 | 4.40 | 25.83 | Good |
| 10 | 4.31 | 27.40 | Good |
| 15 | 4.33 | 26.31 | Good |
| 20 | 4.29 | 24.60 | Good |
| 25 | 3.45 | 20.54 | Medium |
| 30 | 3.28 | 19.50 | Medium |

**Table 2.**Test results of UPV and compressive strength on concrete after 28 days

| Red mud Replacement in (%) | Velocity (km/sec) | Compressive Strength N/mm² | Concrete quality as per IS 13311(part – 1) : 1992 |
|---|---|---|---|
| 0 | 4.05 | 34.79 | Good |
| 5 | 4.34 | 35.82 | Good |
| 10 | 4.01 | 36.72 | Good |
| 15 | 3.90 | 30.33 | Good |
| 20 | 3.61 | 28.31 | Good |
| 25 | 3.36 | 26.93 | Medium |
| 30 | 2.96 | 24.80 | Doubtful |

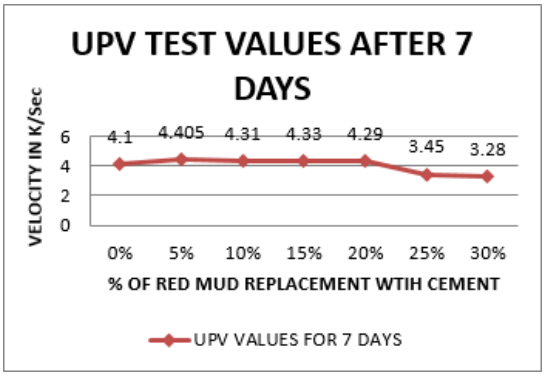


**Fig.1.** UPV Test values after 7 days

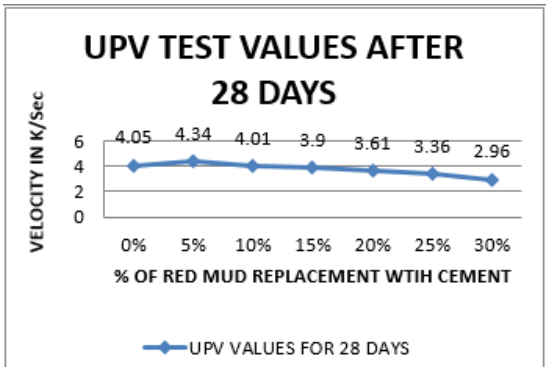


**Fig.2.** UPV Test values after 28 days

**Table 3.** Test result of regression analysis of UPV after 7 days

| Red mud Replacement in (%) | Experimental Values (N/mm²) | Predicted Model Values (N/mm²) | Predicted Model Values/ Experimental Values |
|---|---|---|---|
| 0 | 24.96 | 24.64 | 0.98 |
| 5 | 25.83 | 26.50 | 1.02 |
| 10 | 27.40 | 25.94 | 0.94 |
| 15 | 26.31 | 26.07 | 0.99 |
| 20 | 24.60 | 25.82 | 1.04 |
| 25 | 20.54 | 20.60 | 1.00 |
| 30 | 19.50 | 19.59 | 1.00 |

**Table 4.** Test result of regression analysis of UPV after 28 days

| Red mud Replacement in (%) | Experimental Values (N/mm²) | Predicted Model Values(N/mm²) | Predicted ModelValues / ExperimentalValues |
|---|---|---|---|
| 0 | 34.79 | 34.35 | 0.98 |
| 5 | 35.82 | 37.13 | 1.06 |
| 10 | 36.72 | 36.29 | 1.32 |
| 15 | 30.33 | 36.48 | 1.38 |
| 20 | 28.31 | 36.11 | 1.46 |
| 25 | 26.93 | 28.35 | 1.38 |
| 30 | 24.80 | 26.78 | 1.37 |

COMPRESSIVE_STRENGTH_N_mm2_vs.UPV_K_Sec

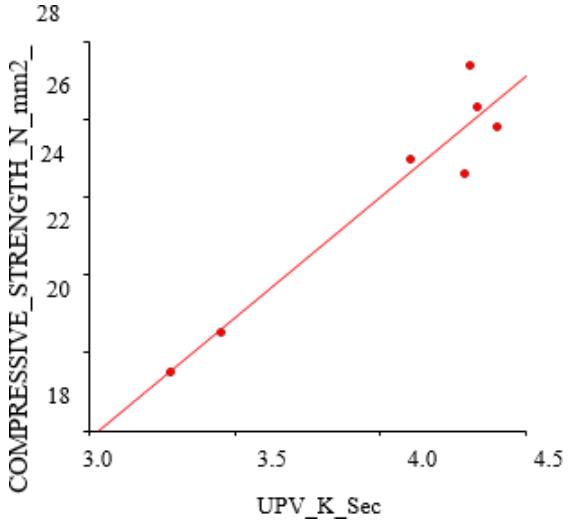


**Fig.3.** Test result of regression analysis of UPV after 7 days

COMPRESSIVE_STRENGTH_N_mm2_vs.UPV_K_Sec

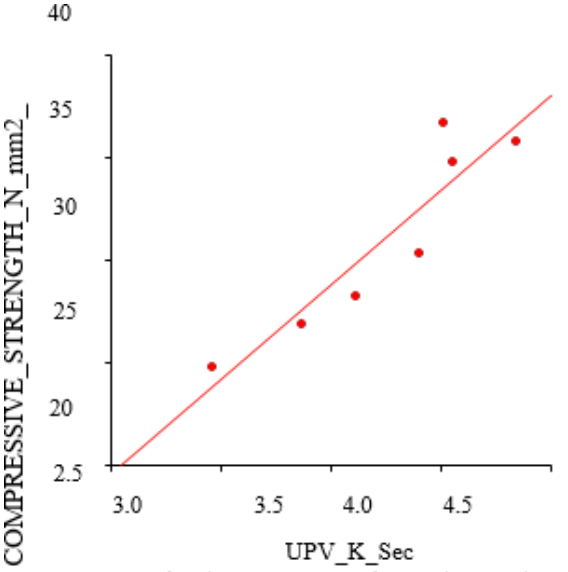


**Fig.4.** Test result of regression analysis of UPV after 28 days

For different percentages of replacing red mud with cement, regression analysis is used to predict the theoretical values between compressive strength and ultra pulse velocity. The experimental values are identical to one another, and a good correlation between the two values is shown by the linear regression analysis. The following regression equations for 7 and 28 days relate compressive strength to UPV values.

Equation (i) 7 days y = -0.8479+6.2172x
$R^2$= 0.9211

Equation (ii) 28 days y = -3.5184+9.2386x
$R^2$= 0.8500
y = compressive strength in N/mm$^2$
x = UPV values in km/sec
$R^2$ = coefficient of determination
The regression analysis of concrete on replacement red mud with cement is tabulated in Table 3 and Table 4.

The predicted model value of 26.50 N/mm2, which is 2.52% greater than the experimental compression value, is obtained from the regression analysis of the UPV after seven days of the substitution of 5% red mud with cement. The substitution of 5% red mud with cement for 28 days results in a predicted model value of 37.13 N/mm2, which is 3.52% higher in cement than the experimental compressive strength value. According to IS : 13311 (part-1) – 1992 the 5% replacement of cement with red for 7 and 28 days the velocity 4.40 km/sec and 4.34 km/sec respectively, which shows good quality of concrete. It indicates that concrete has good quality in terms of homogeneity, density, and lack of imperfections.



## CONCLUSIONS

- Red mud 10% replaced with cement gives higher compressive strength of 27.40N/mm$^2$ and 36.72N/mm$^2$ for 7 and 28 days which has increment of 8.9% and 5.25% respectively than the conventional concrete.
- The ultrasonic pulse velocity test indicated the good quality of concrete at 10% replacement red mud with cement.
- The regression analysis was carried out between UPV and compressive strength for 7 and 28 days respectively. The result shows that the predicted model value obtained from regression analysis gives higher value compared to normal compressive strength when cement is replace with red mud at 5%. So 5% to 10% of red mud in concrete can be used suitably.

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