# Comparative Study on Concrete Strength Under Varying Water Curing Duration

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***Abstract:*** It is mandatory in construction industry that the curing of concrete structure should be carried out as per the standard guidelines to ensure strength and durability criteria over its service life of the structure. Curing of concrete is an empirical process with an assumption to supplement water to the hydration process of cement and to control the moisture movement from the concrete structure. Keeping in view of this criterion a research project has been undertaken to investigate the variation in mechanical properties of concrete with and without curing. For this investigation concrete of grade M30 were used, three mixes were considered one with ordinary Portland cement (OPC), second one with Portland Pozzolana cement (PPC) and another mix with partial replacement of OPC with GGBS as mineral admixture. A series of twenty seven cube specimens were cast for each mix in that nine cubes were cured for Wet cured and six cubes for Partially cured and nine cubes were Air cured, and results obtained from the experiment are compared and conclusions are drawn.

**Keywords:** Fully curing, Partial curing, Not curing, Compressive strength.

## I. INTRODUCTION

It is mandatory in construction industry that the curing of concrete structure should be carried out as per the standard guidelines to ensure strength and durability criteria over its service life of the structure. Curing of concrete is an empirical process with an assumption to supplement water to the hydration process of cement and to control the moisture movement from the concrete structure. Curing is the process of controlling the rate and extent of moisture loss from concrete during cement hydration. When Portland cement is mixed with water, a chemical reaction called hydration takes place. The extent to which this reaction is completed influences the strength and durability of the concrete. Freshly mixed concrete normally contains more water than is required for hydration of the cement; however, excessive loss of water by evaporation can delay or prevent adequate hydration. The curing period may depend on the properties required of the concrete, the purpose for which it is to be used, and the ambient conditions, i.e., the temperature and relative humidity of the surrounding atmosphere. Curing of concrete must begin as soon as possible after placement & finishing and must continue for a reasonable period of time as per the relevant standards, for the concrete to achieve its desired strength and durability. Curing may be applied in a number of ways and the most appropriate means of curing may be dictated by the site or the construction method. Uniform temperature should also be maintained throughout the concrete depth to avoid thermal shrinkage cracks. Also protective measures to control moisture loss from the concrete surface are essential to prevent plastic shrinkage cracks.

## II. LITERATURE REVIEW

**D.Gowsika, et al** evaluated effectiveness of different curing methods and study the persuade of climate on the strength properties of concrete. Normal concrete was prepared with a water-cement ratio of 0.45. The specimens were cast for testing the compressive strength at 7, 14 and 28 days of curing respectively using seven curing methods namely Ponding, Air Drying, Immersion, Oven curing, calcium chloride (miscellaneous), Membrane curing and Pack (Plastic sheeting) curing to cure the specimens until the day of testing. Test results indicates that water curing (WAC) Immersion , Ponding as well as Membrane curing provide much better results than Plastic Sheeting method of curing. The rate of drying was important when the specimens were subjected to Oven method of curing. The overall finding of this paper suggests that concrete should be cured by water curing to attain a better compressive strength.

**Akinwumi, I.I., Gbadamosi, Z.O**. have the results of an experimental study on the effects of curing methods and curing ages on the compressive strength development of ordinary Portland cement concrete in a tropical environment. Fifteen (15) concrete cubes each were cured by immersion in potable water, immersion in lime water, covering with wet rug, covering with plastic sheets and air-drying. For each of these curing methods, the average compressive strength of concrete cubes was determined after 3, 7, 14, 28 and 90 days curing periods. The results obtained discourage the use of curing by air-drying method and also suggests limiting the use of the other curing methods to 28-days period. Generally, the highest compressive strength was obtained for concrete cured by immersion in lime water.

**T. James, et al.** investigated the different curing methods are usually adopted to evaluate the compressive strength of concrete. This study reports the laboratory results of the effect of curing methods on the compressive strength as well as the density of concrete. A total of 72 cubes of mix ratio 1:2:4 were Investigated after subjecting them to various curing conditions, with the aim of finding which of the curing method is best. The cubes were cured in the laboratory at an average temperature of 28◦C (82.4◦F). The results obtained showed that the average compressive strength values for 7, 14, 21 and 28 days, vary with curing methods.

The results show that ponding had the highest compressive strength and density, followed by wet covering, sprinkling, then uncured for two days, with the totally uncured cubes having the least compressive strength and density as well as highest shrinkage limit. Ponding method of curing was recommended to be the best of all the curing methods.

## III. MATERIALS AND METHODOLOGY

**Cement:** Ordinary Portland Cement of 43 Grade was used for casting of all the specimens. It is tested as per IS 12269:1987 Recommendation.
**Fine Aggregate (FA):** Manufactured sand with specific gravity 2.7 and fineness modulus 3.245 confirming to Zone- II is used.
**Coarse Aggregate (CA) -** Locally available angular crushed aggregates as per IS 383-1970 is used in this experimental work of study. Specific gravity of 2.69 coarse aggregate is determined using the method confirming to Indian Standard 2386.
**Water:** The purpose of use of water is for both mixing and curing and it shall be clean and free from the any of the detrimental materials such as acidic compounds, alkaline, salt substances, sugar compounds, organic materials or other substances that may be harmful to concrete structure potable water which is used for drinking purpose is in general suitable in mixing and for curing of concrete. It is tested as per IS 10500:2012 Recommendation.

**Table. 1 Properties of Water**

| Sl No. | Characteristics | Water Sample (mg/l) | Permissible limit (mg/l) |
|---|---|---|---|
| 1 | pH | 7.2 | 6.5 to 8.5 |
| 2 | Colour | clear | |
| 3 | Taste | Agreeable | - |
| 4 | Odour | Unobjectionable | - |
| 5 | Total Acidity (as mg/L of $CaCO_3$) | 10 | - |
| 6 | Total Alkalinity (as mg/L of $CaCO_3$) | 240 | 250- 600 mg/L |
| 7 | Chlorides | 44.99 | 200- 1000 mg/L |
| 8 | a. Total Hardness | 180 | 200-600 mg/L |
| | b. Calcium Hardness | 110 | - |
| | c. Magnesium Hardness | 70 | - |
| 9 | a. Total solids | 640 | - |
| | b. Total dissolved solids | 160 | 500- 2000 mg/L |
| | c. Total suspended solids | 480 | - |
| | d. Inorganic solids | 520 | - |
| | e. Organic solids(mg/L) | 120 | - |
| 10 | Turbidity | 2 | 10 NTU |

**Chemical admixture (Superplasticizer) -** LaGreen S20 is a low range modified polycarboxylic ether based Superplasticizer for pumpable concrete. The properties of Superplasticizer S20 are tabulated in Table. 2.

**Table. 2 Properties of Superplasticizer**

| | |
|---|---|
| Type | Polycarboxylic based ethers |
| Form | Liquid |
| Colour | Light green |
| Relative Density | 1.1 20°C |
| pH | 6.6 |
| Specific gravity | 1.1 |

**Ground Granulated Blast Furnace (GGBS):** Blast furnace slag is a by-product of iron manufacture. When quenched rapidly with water to a glassy state and fines ground, it develops the property of latest hydraulicity. The proportions of GGBS to be used

in concrete depend upon the job requirements, the usual proportions vary from 10 to 50% by weight of cement. GGBS is a cement replacement basis however, if the purpose is to enhance some aspect of concrete durability. Physical Composition of GGBS is shown in Table. 3

**Table.3 Physical Composition of GGBS**

| Parameter | Specifications |
|---|---|
| Colour | Light grey |
| Specific gravity | 2.85 to 2.95 (2.88) |
| Specific surface | 450 m2/kg |

**Methodology:**

**Table. 4 Details of test specimens prepared**

| Designation | Concrete Matrices |
|---|---|
| CS (M30) | OPC Concrete Specimen |
| PPC(M30) | PPC Concrete Specimen |
| CGS(M30) | Cement + 30% GGBS Concrete Specimen |

**Mix Design –**

Mix Design is one of the process by means of which suitable ingredients in the concrete are selected and in order to determine their relative quantity with object of producing concrete possessing minimum desirable properties like workability in fresh state minimum desirable strength and durability in hardened state. Mix proportion obtained by after mix design is tabulated below.

**Table. 5 Mix proportion for CS(M30)**

| Water | Cement | Fine aggregate | Coarse aggregate | Super Plasticizer |
|---|---|---|---|---|
| **157.6** ltr /$m^3$ | **366.511** kg/$m^3$ | **778.780** kg/$m^3$ | **1232.877** kg/$m^3$ | **1.8325** kg/$m^3$ |
| **w/c 0.43** | **1** | **2.124** | **3.363** | **0.005** |

**Table. 6 Mix proportion for PPC (M30)**

| Water | Cement | Fine aggregate | Coarse aggregate | Super Plasticizer |
|---|---|---|---|---|
| **155** ltr /$m^3$ | **345** kg/$m^3$ | **693** kg/$m^3$ | **1207** kg/$m^3$ | **1.725** kg/$m^3$ |
| **w/c 0.45** | **1** | **2.008** | **3.498** | **0.005** |

**Table. 7 Mix proportion for CG(M30)**

| Water | Cement | GGBS | Fine aggregate | Coarse aggregate | Super Plasticizer |
|---|---|---|---|---|---|
| **157.6** ltr /$m^3$ | **282.214**kg/ $m^3$ | **120.948** kg/$m^3$ | **762.405** kg/$m^3$ | **1206.983** kg/$m^3$ | **1.4110** kg/$m^3$ |
| **w/c 0.39** | **1** | | **1.891** | **2.993** | **0.005** |

## IV. EXPERIMENTAL PROGRAMME

Test specimen and testing procedures for compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast. In this study M30 grade of concrete which are often used for buildings and infrastructure construction are considered. The total experimental program consists of the concrete

**Fig. 1. Compressive strength test**

Specimens were subjected under three curing conditions namely Wet cured (WC), Partially Cured (PC) and Air-Cured (AC). In WC the specimens were cured for 3 days, 7 days and 28 days, in PC the specimens were cured for 3 days in water and later left for air curing and 7day in water and later left for air curing and in AC the specimen after demoulding on next day were left for air curing. Cubes were tested on compression testing machine as per I.S. 516-1959. In each category three cubes were tested and their average value is reported.

**Table. 8 Details of Curing Conditions**

| Designation | Concrete Matrices |
|---|---|
| WC | Wet Cured |
| PC | Partially Cured |
| AC | Air Cured |

## V. RESULTS AND DISCUSSION

The hardened concrete test was done as per IS 516:1959. The results of cube for compressive strength at different ages under three curing conditions (Wet cured, Partial cured, Air-cured) are summarized in below Table. 9

**Table. 9 Compressive Strength of Concrete Cubes.**

| Details of Cube specimens. | Wet Cured, WC | | | Partially Cured, PC | | | Air-Cured, DC | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3 days | 7 days | 28 days | 3 days | 7 days | 28 days | 3 days | 7 days | 28 days |
| CS | 14.96 | 22.84 | 31.85 | 19.10 | 24.59 | 31.85 | 9.32 | 11.38 | 13.32 |
| PPC | 15.70 | 25.33 | 32.74 | 21.03 | 26.14 | 32.74 | 9.92 | 12.29 | 14.96 |
| CGS | 13.62 | 22.21 | 32.73 | 18.51 | 22.96 | 32.73 | 9.18 | 11.40 | 13.32 |

The Fig. 2, 3 & 5 shows Cubes Compressive Strength of CS at different ages under three curing conditions (Wet cured, Partial cured & Air-cured). Fig. 4 shows shows the Percentage variation of Cubes Compressive Strength of CS(AC) with respect to CS(WC).

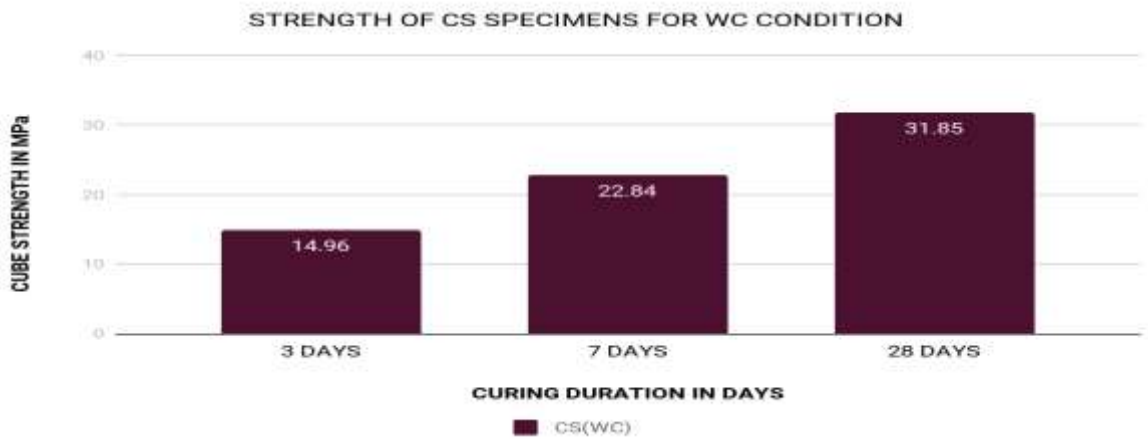



**Fig. 2 Cube Compressive Strength of CS for WC condition.**

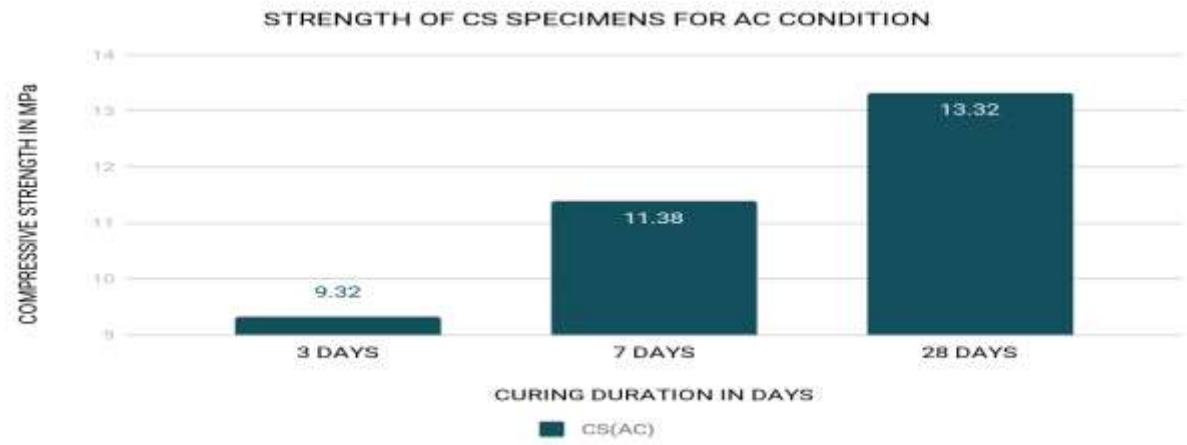



**Fig. 3 Cube Compressive Strength of CS for AC condition.**

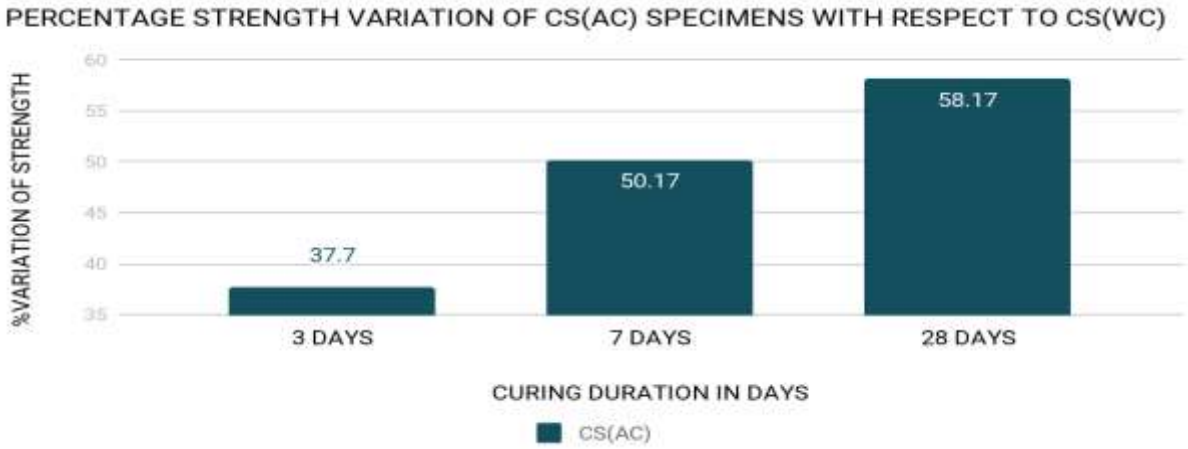



**Fig. 4 Percentage variation of Cube Compressive Strength of CS(AC) specimens with respect to CS(WC).**

The reduced compressive strength under AC conditions specimens is compared with WC condition specimen for CS, the average percentage cube strength reduction for 3 days, 7 days and 28 days is 37.71%, 50.17% and 58.17% respectively.

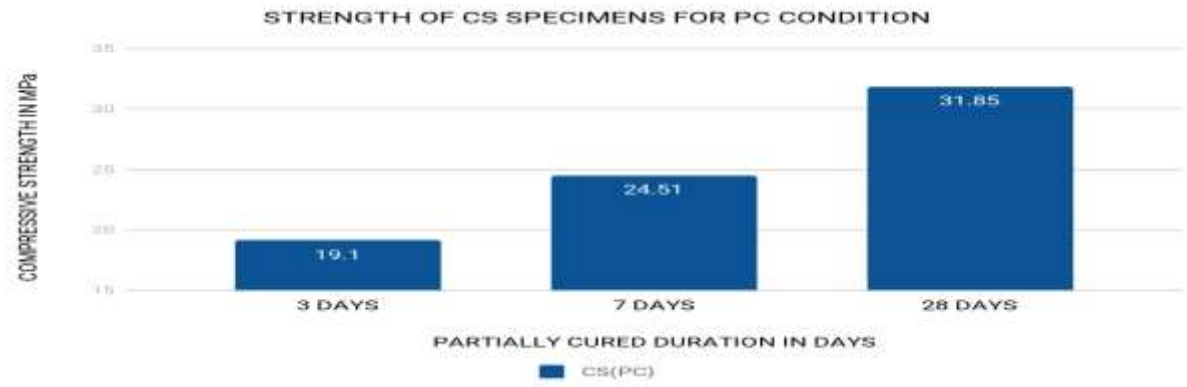



**Fig. 5 Cube Compressive Strength of CS for PC condition.**

Fig. 6 shows the Variation of cube compressive strength of CS(PC) specimens with 28 days strength of CS(WC) specimen and Fig. 7 shows Percentage Variation of cube compressive strength of CS(PC) specimens with 28 days strength of CS(WC) specimen.


**Fig. 6 Variation of Cube Compressive Strength of CS(PC) specimens with 28 Days Strength of CS(WC) specimen.**

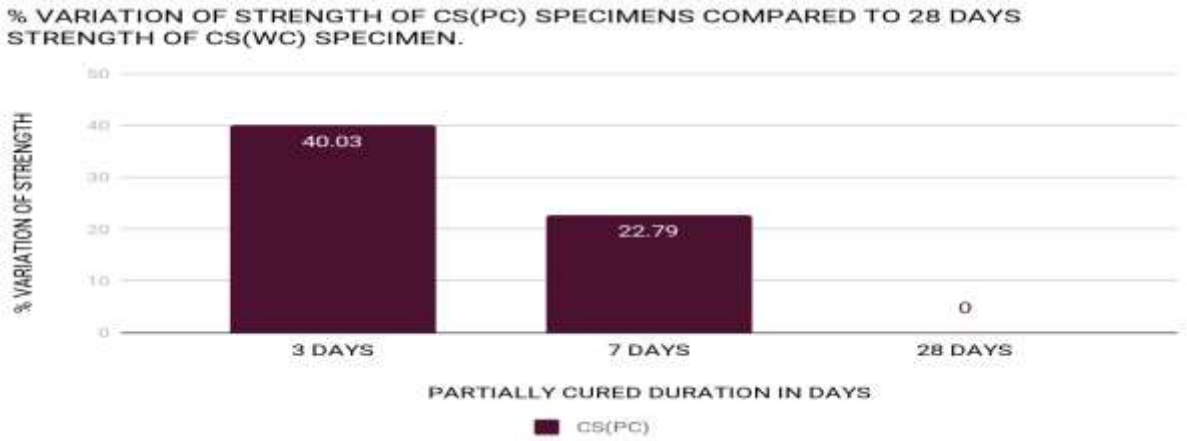



**Fig. 7 Percentage variation of Cube Compressive Strength of CS(PC) specimens with 28 DAYS strength of CS(WC) specimen.**

The variation of compressive strength CS specimens under PC condition is compared with 28 days compressive strength of WC condition specimen for CS, the average percentage cube strength reduction for 3 days, 7 days and 28 days of partially cure is 40.03%, 22.7% and 0% respectively.

The Fig. 8, 9 & 11 shows Cubes Compressive Strength of PPC at different ages under three curing conditions (Wet cured, Partial cured & Air-cured). Fig. 10 shows the Percentage variation of Cubes Compressive Strength of PPC(AC) with respect to PPC(WC).

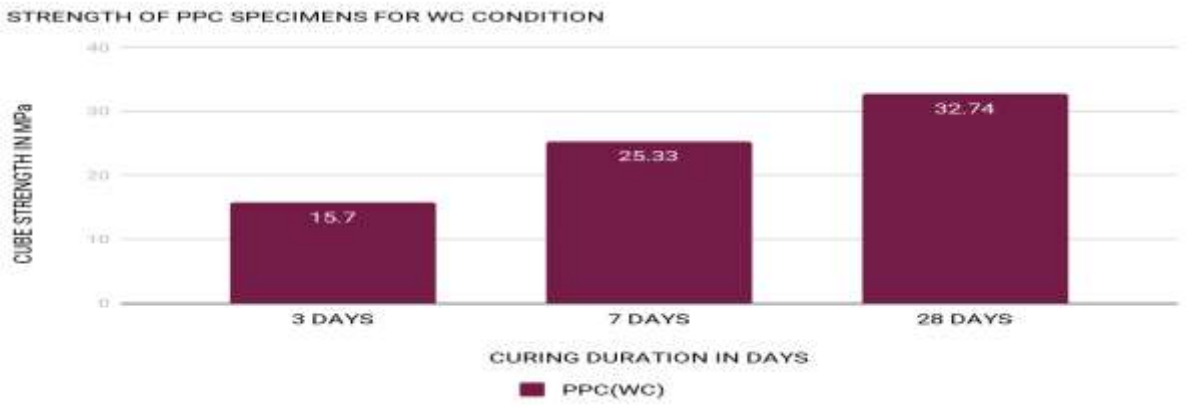



**Fig. 8 Cube Compressive Strength of PPC for WC condition.**

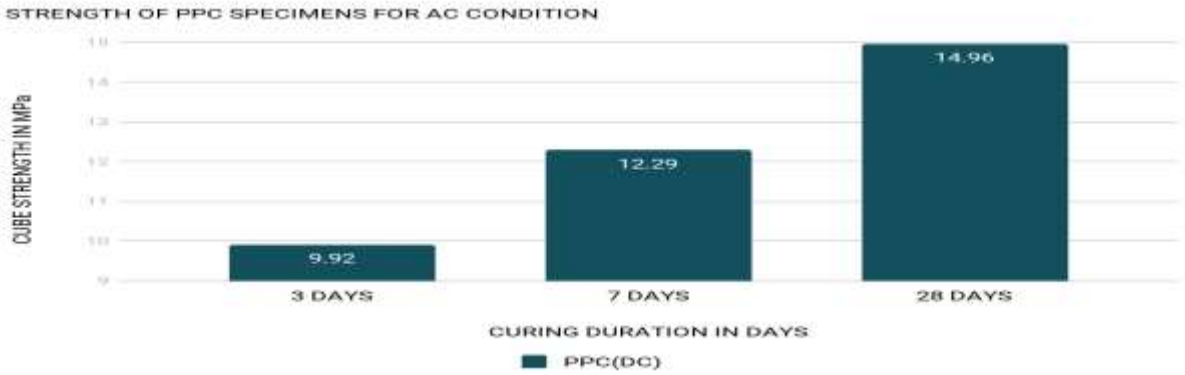



**Fig. 9 Cube Compressive Strength of PPC for AC condition.**

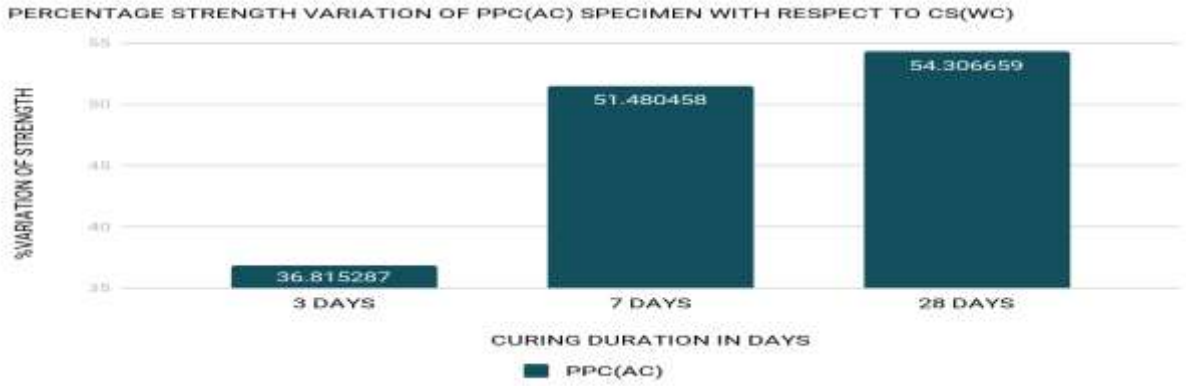



**Fig. 10 Percentage variation of Cube Compressive Strength of PPC(AC) specimens with respect to PPC(WC).**

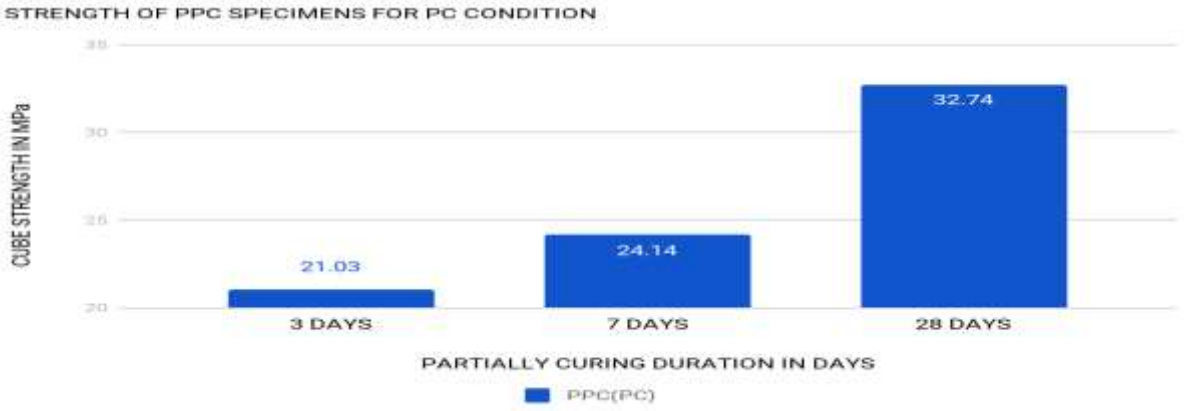



**Fig. 11 Cube Compressive Strength of PPC for PC condition**

Fig. 12 shows the Variation of cube compressive strength of PPC(PC) specimens with 28 days strength of PPC(WC) specimen and Fig. 13 shows Percentage Variation of cube compressive strength of PPC(PC) specimens with 28 days strength of PPC(WC) specimen.

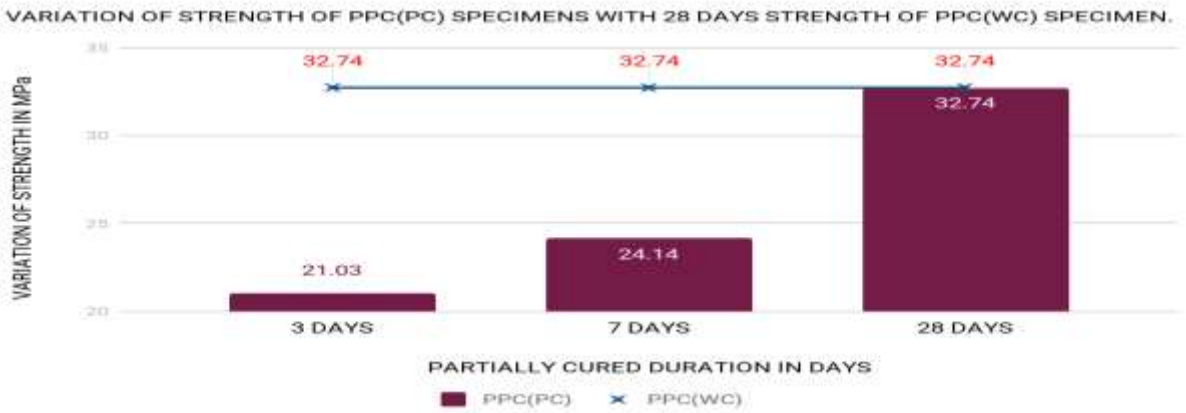



**Fig. 12 Variation of Cube Compressive Strength of PPC(PC) specimens with 28 days strength of PPC(WC) specimen.**

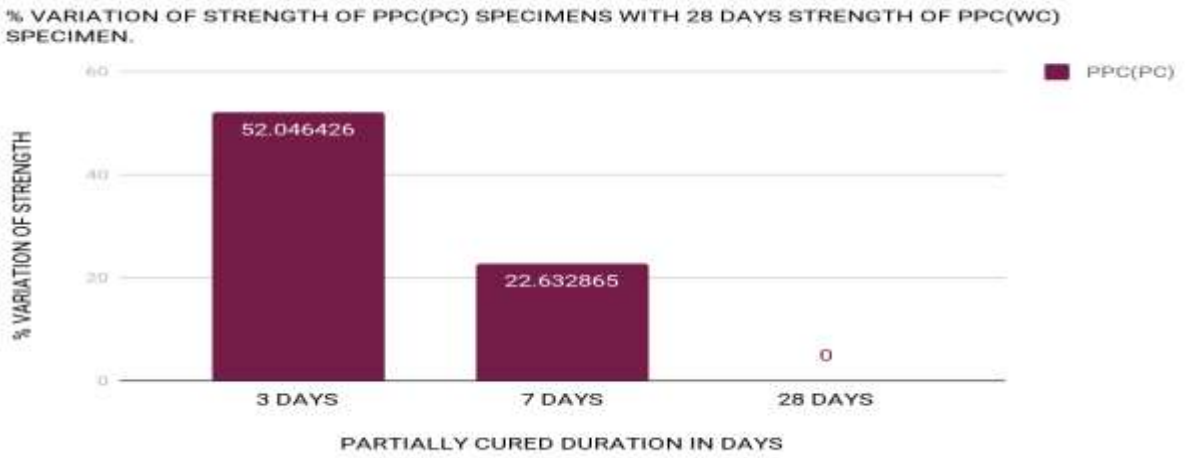



**Fig. 13 Percentage variation of Cube Compressive Strength of PPC(PC) specimens with 28th Day Strength of PPC(WC) Specimen.**

The variation of Compressive strength of PPC for PC condition is compared with 28 days compressive strength of PPC for WC condition, the average percentage cube strength reduction for 3 days, 7 days and 28 days of partially cure is 52.04%, 22.63% and 0% respectively.

The Fig. 14, 15 & 17 shows Cubes Compressive Strength of CGS at different ages under three curing conditions (Wet cured, Partial cured & Air-cured). Fig. 16 shows the Percentage variation of Cubes Compressive Strength of CGS(AC) with respect to CGS(WC).

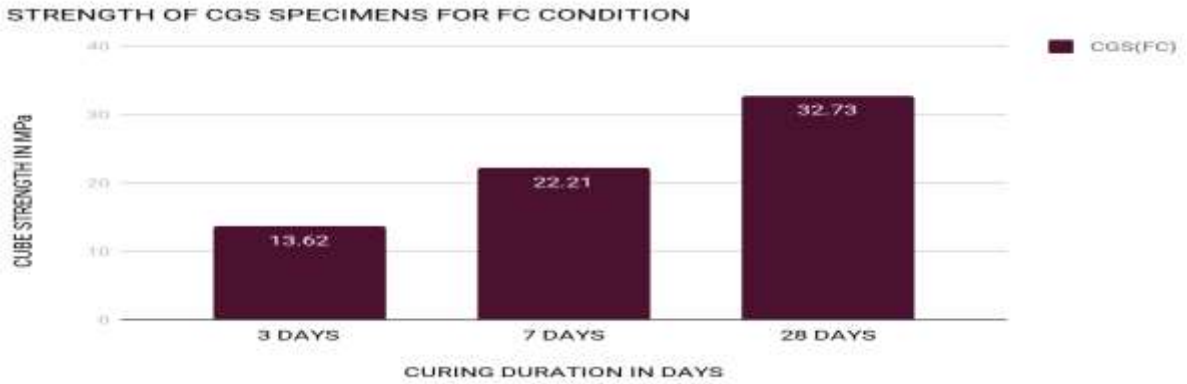



**Fig. 14 Cube Compressive Strength of CGS for FC condition.**

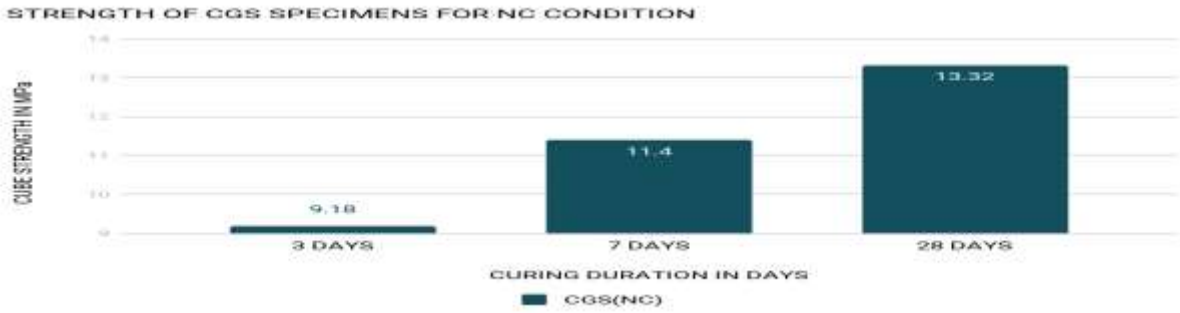



**Fig. 15 Cube Compressive Strength of CGS for NC condition.**

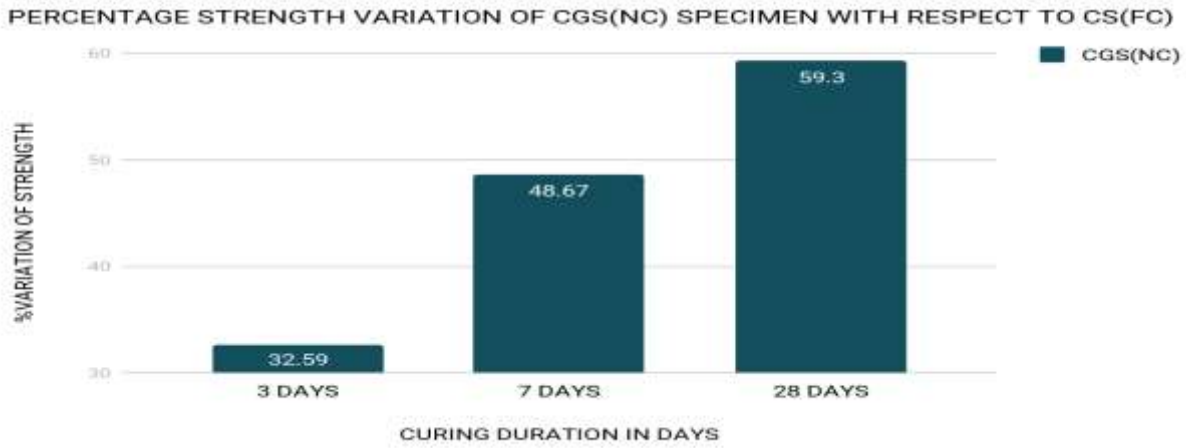



**Fig. 16 Percentage variation of Cube Compressive Strength of CGS(NC) specimens with respect to CGS(FC).**

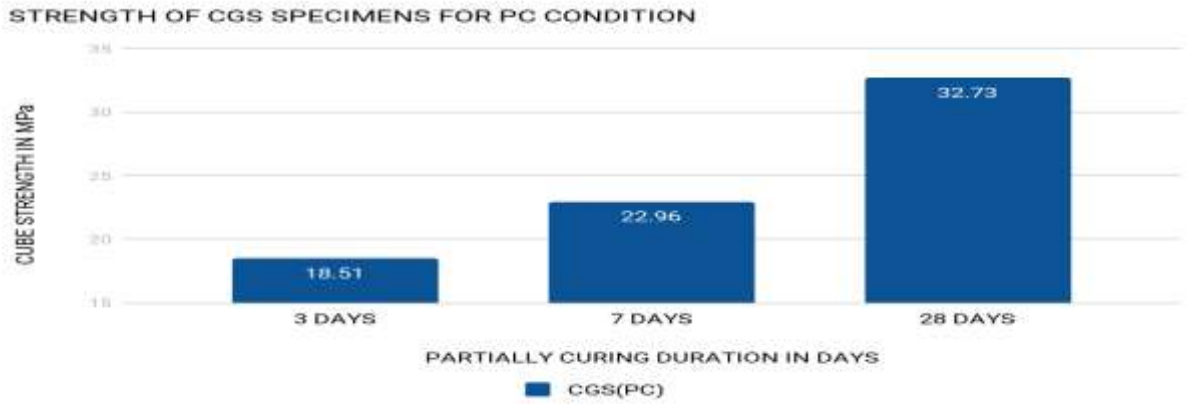



**Fig. 17 Cube Compressive Strength of CGS for PC condition.**

Fig. 18 shows the Variation of cube compressive strength of CGS(PC) specimens with 28 days strength of CGS(WC) specimen and Fig. 19 shows Percentage Variation of cube compressive strength of CGS(PC) specimens with 28 days strength of CGS(WC) specimen.

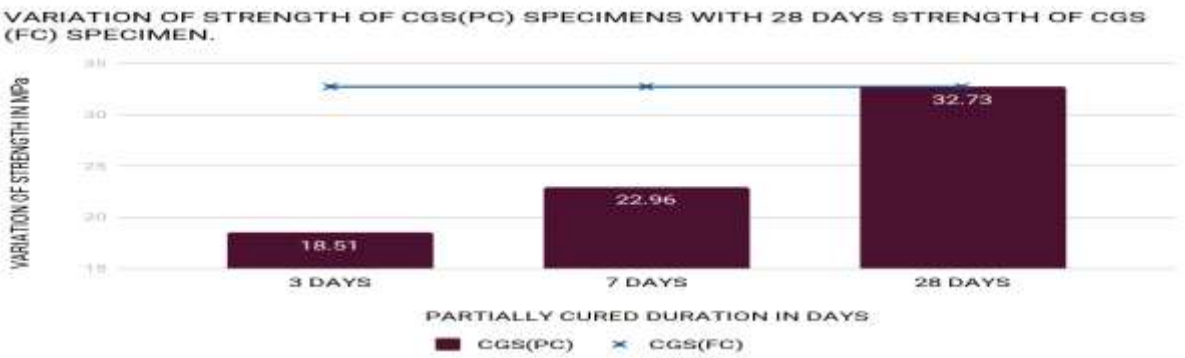



**Fig. 18 Variation of Cube Compressive Strength of CGS(PC) specimens with 28 days strength of CGS(FC) specimen.**

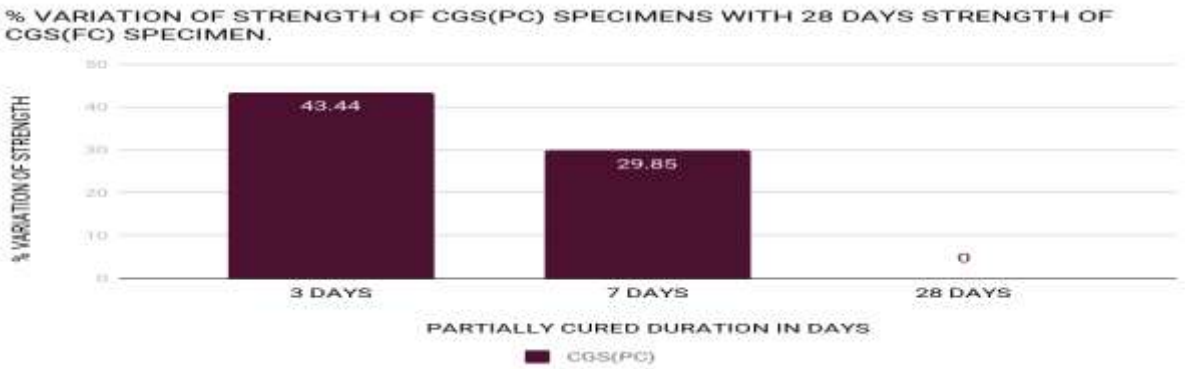



**Fig. 19 Percentage variation of Cube Compressive Strength of CGS(PC) specimens with 28th Day Strength of CGS(FC) Specimen.**

The variation of Compressive strength of CGS for PC condition is compared with 28 days compressive strength of CGS for WC condition, the average percentage cube strength reduction for 3 days, 7 days and 28 days of partially cure is 43.44%, 29.85% and 0% respectively.

The Fig. 20 shows Cubes Compressive Strength Curves for CS(PC), PPC(PC) and CGS(PC) for various Curing durations, which shows the 28th day cube compressive strength for different curing durations.

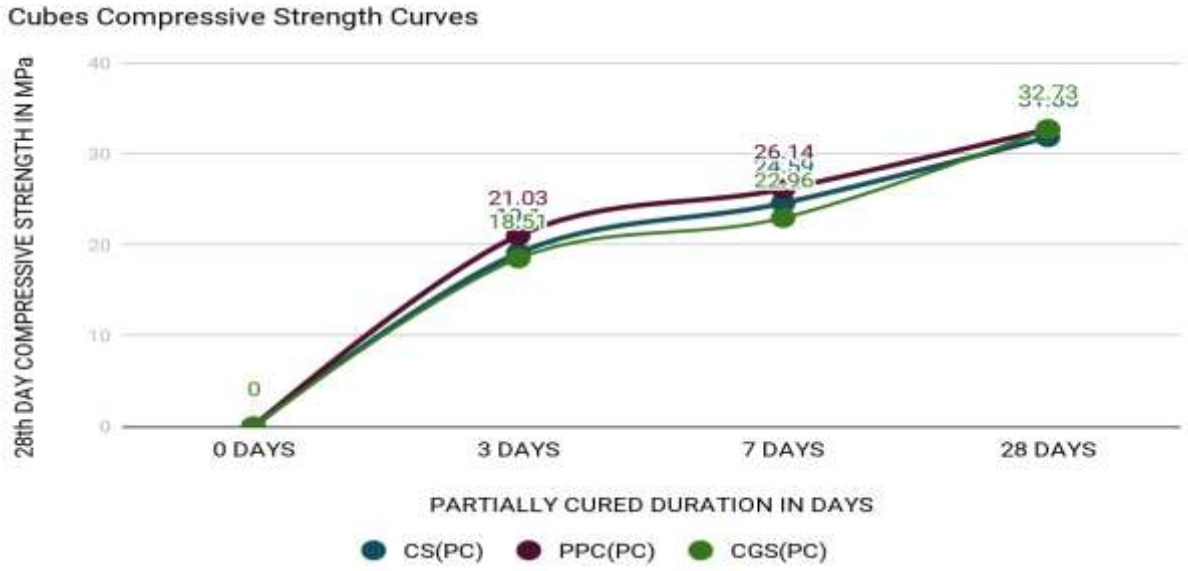



**Fig. 20 Cubes Compressive Strength Curves of CS(PC), PPC(PC) and CGS(PC) Specimens.**

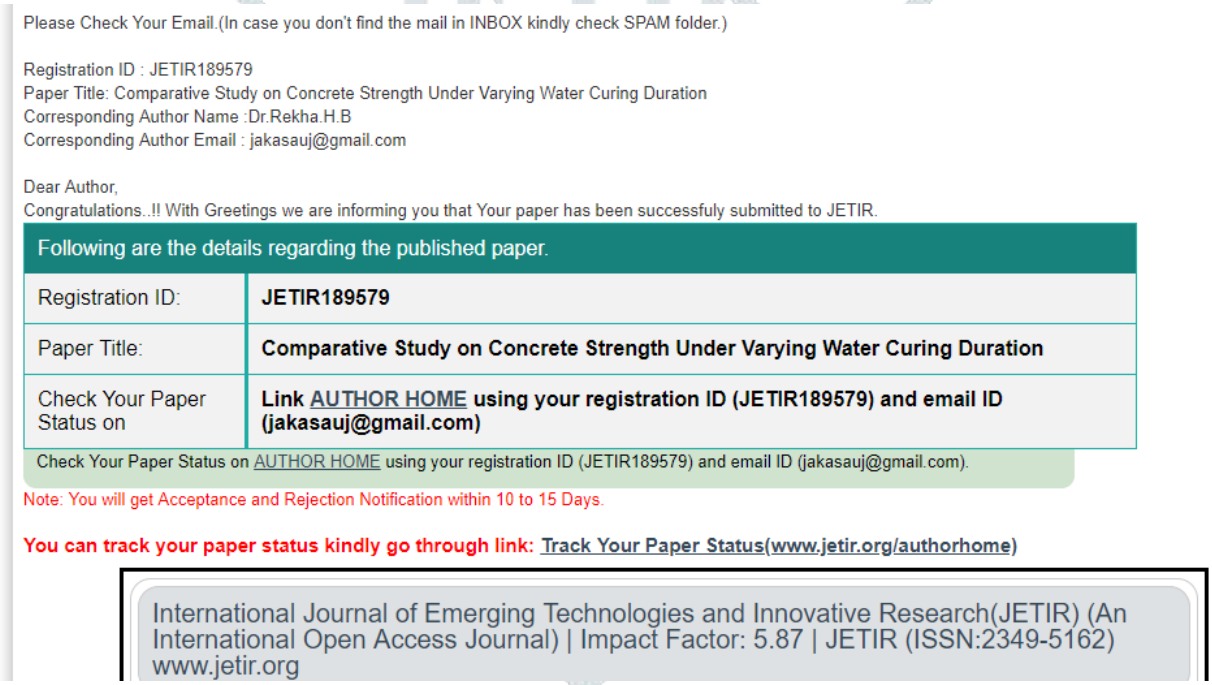
## V. CONCLUSION

Based on the above experimental results it can be concluded that the compressive strength of cube specimens for Air cured(AC) condition and compressive strength of cube specimens for water cured(WC) condition shows so much variation which is not desirable. It can also be concluded that the there is no much change in the strength due the replacement of GGBS by cement. Even though the compressive strength of cube specimens for Partially cured condition(PC) compared with 28 days compressive

strength of cube specimen for Wet cured(WC) condition shows less variation than that of Air cured(AC) condition it failed to achieve the desirable strength. The Cube Compressive Strength Curves helps to estimate the strength of CS, PPC and CGS for a known curing duration, which would be useful in construction field to evaluate actual strength of concrete.

## VI. REFERENCES


1. Indian standard code of ordinary portland cement - specification IS:269:2015, Bureau of Indian Standards (BIS), New Delhi, India.
2. Kholia, Binitas, Tank, " Effect on concrete by different curing method and efficiency of curing compounds - A Review" International journal of The physical sciences Vol.5(9),Pp.1419-1423,18 August, 2010.
3. B Sivarama Sarma, R Selvam and R Devendran, "Curing of concrete, is it a National comfort or a technical solace in present day environment?", April, 2018.
4. Indian standard code of practice for coarse and fine aggregate for concrete - specification IS:383:2016, Bureau of Indian Standards (BIS), New Delhi, India.
5. Indian standard code of practice for method of sampling and test for water and waste water - specification IS:3025:1988, Bureau of Indian Standards (BIS), New Delhi, India.
6. Indian standard code of practice for plain and reinforced concrete - IS:456:2000, code of practice, Bureau of Indian Standards (BIS), New Delhi, India.
7. Indian standard code of practice for concrete admixtures - specification IS:9103-1999, Bureau of Indian Standards (BIS), New Delhi, India.
8. Indian standard code of practice for concrete mix proportioning - guidelines IS:10262:2009, Bureau of Indian Standards (BIS), New Delhi, India.

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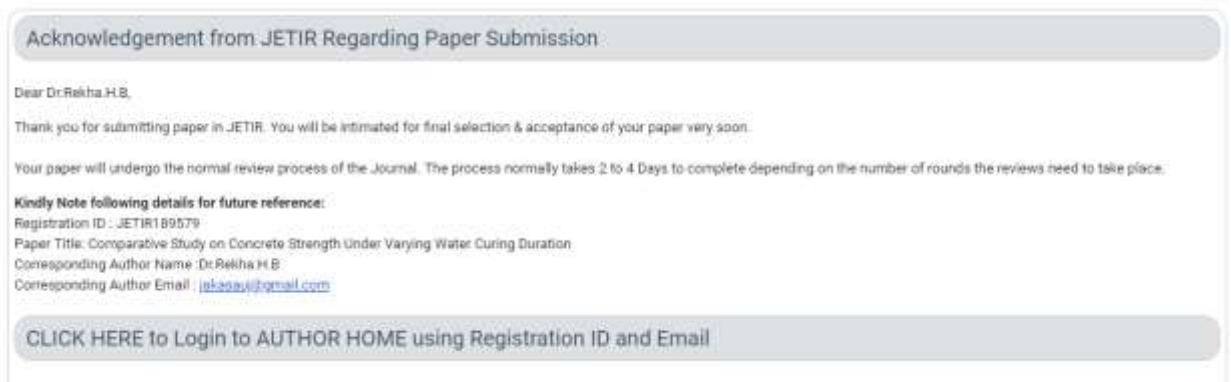

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