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Development of Compressive Strength of Concrete under Different Curing Conditions

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Abstract – *Curing is the process used for promoting the hydration of cement. Curing consists of the control of temperature and moisture movement from and into placed concrete; with the aim of keeping the concrete saturated or as nearly saturated as possible, until the originally water-filled space in the fresh cement paste has been filled to the desired extent by the products of cement hydration. Proper curing reduces the rate of moisture loss and provides a continuous source of moisture required for hydration. Thereby reduces the porosity and provides a fine pore size distribution in concrete. The purpose of this investigation was to conduct a laboratory test program on how much different curing conditions affect the attainable strength of concrete. To achieve this purpose, a laboratory test program was conducted. The laboratory program consisted of casting 150 mm by 150 mm concrete cubes of M25 grade mix design and subjecting them to four different curing conditions. In order to investigate the influence of curing conditions, on the compressive strength of concrete cubes, for each mix design three cubes were chosen for every curing regime. The curing regimes employed were: immersion in drinking water; covering with wet burlap sheets; and wrapping with plastic sheeting (PSC). For all curing conditions, the compression tests were performed at the age of 7 & 28 days. It has been found that the curing system greatly influences the concrete strength. While the highest gain in compressive strength was recorded for cubes immersed in water and then for cubes covered with wet burlaps sheet, the lowest gain in compressive strength was recorded for the specimens cure using wrapping with plastic sheeting (PSC).*

Key Words**: Concrete, Compressive strength, Curing systems**

1. INTRODUCTION

Concrete is a mix of cementitious (binding) solids [e.g., cement (calcium silicates, calcium aluminates, and calcium alumino-ferrites) and sometimes fly ash (aluminates and silica) and micro-silica], aggregate (sand and stones), and water. The cementitious solids of concrete, upon mixing with water, react in highly exothermic, temperature-dependent hydration reactions (the higher the temperature, the faster the hydration reactions) producing a firm, hard mass.

There are four major stages in the hydration reactions:
1) Surface reactions produce a "gel" on cementitious particles and release heat, lasting about 30 min,
2) Hydration is slowed for several hours because diffusion of water into the cement particle is inhibited by the gel,
3) vigorous hydration and heat development occur for up to 20 h as water reaches un-hydrated cement inside the gel coating (stiffening of the concrete occurs during this stage), and
4) Hydration continues to decline for years.

To ensure that hydration continues, especially at the surface, the concrete must be cured. Curing means water at the surface of the concrete is retained to allow the concrete to hydrate to a point where it has a strong, durable structure. If curing is inadequate, the water evaporates and hydration stops, resulting in a low-strength concrete. If adequate moisture isn't maintained in the curing environment, the concrete won't develop maximum compressive strength, and cracking may occur. Durability of the concrete may also be reduced due to inadequate hydration of the cementitious material. Ambient atmospheric conditions can adversely influence the thermal and moisture structure of freshly poured concrete. If concrete becomes too warm or temperature gradients too large during the first several days after the concrete is poured or if there is insufficient water in the concrete, the concrete may crack or may not develop its maximum potential strength, reducing its long-term durability [4-7] .Surface drying may even affect the underlying concrete, as water will be drawn from the lower levels into the dry surface concrete. Any significant internal drying also will slow or stop hydration and the structure may not gain adequate strength. For hydration to continue, the relative humidity inside the concrete has to be maintained at a minimum of 80%. If the relative humidity of the ambient air is that high, there will be little movement of water between the concrete and the ambient air and no active curing is needed to ensure continuation of hydration. Prevention of the loss of water from the concrete is of importance not only because the loss adversely affects the development of strength, but also because it leads to plastic shrinkage, increased permeability and reduced resistance to abrasion.

2. LITERATURE REVIEW

Concrete curing is one of the most important and final steps in concrete construction though it is also one of the most neglected and misunderstood procedures. It is the treatment of newly placed concrete during the period in which it is hardening so that it retain enough moisture to immunize shrinkage and resist cracking (Lambert Corporation, 1999). Curing of concrete is a pre requisite for the hydration of the cement content. For a given concrete, the amount and rate of hydration and furthermore the physical make-up of the hydration products are dependent on the time-moisture-temperature history (Neil Jackson et al, 1996).

The necessity for curing arises from the fact that hydration of cement can take place only in water-filled capillaries. This is why loss water must be prevented. Furthermore, water lost internally by self-dedication has to be replaced by water from outside, i.e.ingress of water into the concrete must take place. (Neville,et al,1987). Thus, for complete and proper strength developments, the loss of water in concrete from evaporation should be prevented, and the water consumed in hydration should be replenished. This the concrete continues gaining strength with time provided sufficient moisture is available for the hydration of cement which can be assured only by creation of favourable conditions of temperature and humidity. This process of creation of an environment during a relatively short period immediately after the placing and compaction of the concrete, favourable to the setting and the hardening of concrete is termed curing (Gambir, 1986).

A proper curing maintains a suitably warm and moist environment for the developments of hydration products, and thus reduces the porosity in the hydrated cements paste and increases the density of microstructure in concrete. The hydration products extend from the surfaces of cement grains, and the volume of pores decreases due to proper curing under appropriate temperature and moisture (Safiudeen et al,2007). A proper curing greatly contributes to reduce the porosity and drying shrinkage of concrete, and thus to achieve higher strength and greater resistance to physical or chemical attacks in aggressive environments. Therefore, a suitable curing method such as water ponding (immersion), spraying or sprinkling of water, or covering with polythene sheet material is essential us order to produce strong and durable concrete.

The study present the effect of different curing methods on the compressive strength of concrete using Portland cement and finally identifies the most effective curing process for normal concrete.

3. MATERIALS

The materials used in the preparation of Concrete are:
1. Cement
2. Fine aggregate i.e., Natural Sand
3. Coarse aggregate
4. Water

To produce good quality of concrete we need good quality ingredients which satisfy the Standards. Hence tests on different ingredients mentioned above are conducted as per IS standards which are presented below. Properties are represented in the form of Tables for every material used in the production of Concrete.

3.1 Cement

Portland Pozzolana Cement of 43 grade of AMBUJA brand confirming to I.S is used in the present work. The cement is tested for its various properties as per IS: 4031 – 1988 and found to be confirming to the requirements as per IS: 1489-1999 Part-1. In order to avoid the possible variation in the properties of cement from various batches all the specimens are prepared from the same batch of cement. The results of tests concluded on cement are as follows.
Cement - Portland Pozzolana Cement
Brand Name - Birla gold cement
Specific Gravity - 3.1

3.2 Fine Aggregate – Natural Sand:

Sand which is passed on 4.75mm sieve & retained on 150µ sieve are used

Physical Properties of Natural Sand

S.NO	PROPERTY	VALUE	REQUIREMENTS AS PER IS 383
1	Fine Aggregate	Sand	As per Indian Standards
2	Specific Gravity	2.65	2.6-2.8
3	Water Absorption	0.25%	Should not be > 1% for construction
4	Density	1450 gm/cc	Within the Code Provisions
5	Fineness Modulus	2.74	2.6-2.9

Table -1: properties of natural sand

3.3 Coarse Aggregate:

The Coarse aggregate is free from clay matter, silt and organic impurities etc. the coarse aggregate is also tested for specific gravity and it is 2.82, fineness modulus of coarse aggregate is 4.07. Aggregate of normal size 20 mm downgraded 60% passed on 20.0 mm sieve and remaining 40% is taken from the sieve 10.0 mm (passing) and 4.75 mm (retained) is mostly used in the experimental works, which is acceptable according to IS: 383– 1970

Properties of Coarse Aggregate

S .no	Property	Value	Requirements as Per IS 383
1	Coarse Aggregate	Machine crushed granite	Within the Code Provisions
2	Specific Gravity	2.75	2.6 to2.8
3	Water Absorption	0.33%	Should not be >1%
4	Fineness Modulus	7.78	6.5-8.5
5	Shape Tests a)Elongatio		as per IS 2386part 1, the flakiness

Table -2: properties of coarse aggregates

3.4 Water:

About 38% of cement At Normal Room Temperature = 550ml.

3.5 EXPERIMENTAL PROGRAM

Mix Design

The selection of suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible is termed the concrete mix design. The mix design of the concrete has been carried out based on IS 10262 – 2009. In this Experimental study we are using M-25 grade concrete. The factors affecting the strength of concrete at a given age and cured at prescribed temperature is the degree of compaction.

The concrete mixture was proportioned to have a minimum slump of 48mm and also a minimum compacting factor or 0.94. The concrete mixture was assumed to be fully compacted and the proportions of the materials were determined on the basis of absolute volume of the constituents. The details of mixture proportions are given is below

Cement – 380 kg/m^3
Sand – 691 kg/m^3
Coarse aggregate (20mm)- 1170 kg/m^3
Water -190 kg/m^3

Testing of Fresh Concrete

The fresh concrete was produced using manual method of mixing in the laboratory. Immediately after mixing, the fresh concrete was tested for slump and compacting factor. The slump and compacting factor tests were determined according to IS: 1199 - 1959

Preparation of Test Specimens

A total of 24 cubes having dimensions 150mm x 150mm x 150mm each were cast. The specimens were moulded in oiled steel moulds using three layers of filling and each layer tamped 25 times to expel the entrapped air. The tops of the cubes were marked after a while for identification purpose. Immediately after this, the specimens were kept in a cool place in the laboratory. The specimens were removed from the moulds at the age of 24+ – 2 hours.

Curing Methods

The test specimens were cured under four types of curing until the day of testing. These were water curing(WAC), Covering with wet burlap sheets(WBS), Sprinkling of water (SWC) and Wrapping with plastic sheeting (PSC).In water curing, the specimens were weighed and immersed in water. Portable borehole water was used in water curing. In sprinkling method, the specimens were also weighed and kept moist by sprinkling water on the specimens 2 times daily (morning and evening) until the date of testing. In plastic sheeting, the specimens were weighed and wrapped in flexible plastic sheets until the testing date. At least 2 layers of wrapping were used to prevent moisture movement from concrete surface. The curing temperature was maintained at 27 + 2^{o}C in all the curing methods.

Testing of the hardened concrete

The compressive strength of the test cubes were determined by crushing the cubes under the compression machine. A total of 24 cubes in all were crushed, 6 of these cubes were for immersion method, the 6 cubes were for sprinkling method, 6 cubes were for wet covering burlaps, while the last 6 cubes were for membrane method (Polythene Sheet). The length of curing dates considered was7 and28 days respectively.

4. RESULTS AND DISCUSSIONS

All the tests have been performed in standard procedures and the results and load values obtained were tabulated and calculated in following sections.

4.1. Fresh Properties

The slump and compacting factor of the concrete were 48mm and 0.94 respectively indicating that the concrete mix has adequate mobility and stability i.e the mix fall within the range of medium workability.
The average result of 0.94 obtained as the compacting factor indicated that the concrete can be manually compacted. The concrete can also be used for heavily reinforced sections with vibrations.

4.2 Compressive Strength

Compressive strength tests were conducted on cured cube specimen at 7 days and 28 days age using a compression testing machine of 200 kN capacities. The cubes were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

S.No	Curing Method of Cube	Trial	Compressive strength (7 days) N/mm²	Compressive Strength (28 days) N/mm²
1	Cubes cured by immersion	T1	18.10	28.21
		T2	18.25	29.5
		T3	18.40	28.1
		Avg	**18.25**	**28.60**
2	Cubes cured by sprinkling of water	T1	14.99	26.22
		T2	15.82	25.76
		T3	16.66	24.11
		Avg	**15.92**	**25.36**
3	Cubes cured by membrane method (Polythene Sheet)	T1	13.96	22.36
		T2	14.37	23.75
		T3	14.28	23.19
		Avg	**14.20**	**23.12**
4	Cubes cured by wet burlaps	T1	16.54	25.7
		T2	15.86	26.67
		T3	17.79	26.96
		Avg	**16.73**	**26.4**

Table -4.2: Compressive Strength values

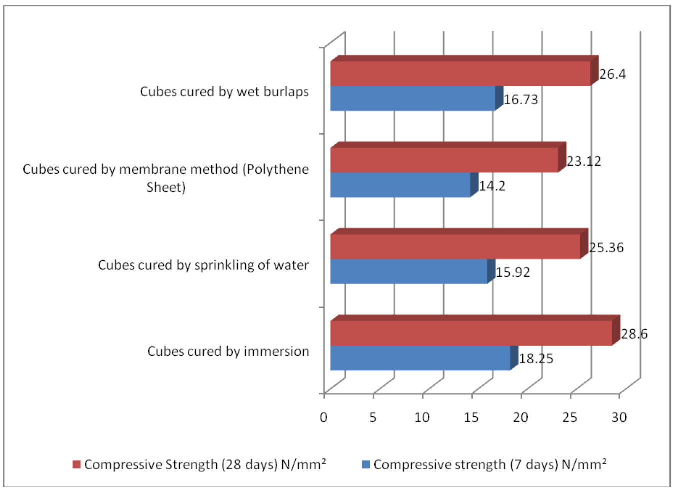

Chart -4.2: Compressive Strength

The results of compressive strength have been presented in table 4.1 and in the graphical representation of average compressive strength versus curing age for different methods of curing used in the experiment (see fig 4.2).

In all these curing methods, the compressive strength of the concrete increases with age. The highest compressive strength at all ages was produced by immersion (water) curing. The average compressive strength of water cured concrete was 18.25 N/mm² and 28.60 N/mm² at 7 and 28 days respectively.

Cubes cured by wet burlaps method produced compressive strength close to immersion (Water) curing.

The development of higher compressive strength in immersion (Water) curing, wet burlaps and sprinkling method of curing is credited to sufficient moisture and suitable vapour pressure, which were maintained to continue the hydration of cement.

Plastic sheeting (membrane) method of curing produced the lowest compressive strength at all ages. It caused a reduction in compressive strength of 4.05N/mm² and 5.48N/mm² at 7 and 28 days, respectively, as compared to water curing. The early drying of concrete stopped the cement hydration before the pores were blocked by adequate calcium silicate hydrate.

5. SUMMARY AND CONCLUSIONS

From the results presented and discussed in this paper following conclusions can be made:

Different curing systems have different effects on the compressive strength of concrete.

Among the curing systems employed in this research, curing by immersion produced the highest concrete compressive strength followed by covering with wet burlaps sheets.

Water curing was the most effective method of curing. It produced the highest level of compressive strength. This is due to improve pore structure and lower porosity resulting from greater degree of cement hydration reaction without any loss of moisture from the concrete specimens.

Sprinkling method of curing produces higher compressive strength than plastic sheeting. This is attributed reduced the moisture movement from concrete specimens leading to enhanced degree of cement hydration.

Plastic sheeting method of curing produces lowest level of compressive strength. This is because the moisture movement from the concrete specimen is higher in plastic sheeting method, which did not provide and any protection against early drying out of concrete. Hence hydration of cement reaction was abated.

The extent of moisture movement was greatly dependent of the method of curing. Greater moisture movement occurs under plastic sheeting (membrane) method, and it significantly affected the strength property of the concrete.

Normal concrete should be cured by water curing (immersion) method in order to achieve good hardened properties. Water curing produces no loss of moisture, and therefore enhances cement hydration reaction. In case of water shortage, sprinkling curing can be adopted instead of wrapped (plastic sheeting) curing.

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REFERENCES

"Cement, Concrete & Aggregates Australia" (CCAA), Data sheet, April 2006, pages 1-7.
"National Ready Mixed Concrete Association" (NRMCA), Data sheet, CIP-11-Curing In Place Concrete, pages 1&2.
Kosmatka Steven H, Kerkhoff Beatrixa & Panarese William C, "Design and Control of Concrete Mixtures", EB001, 14th edition, Portland Cement Association, pages 219-223.
Vincent T. H. CHU, "A Closer Look at Prevailing Civil Engineering Practice – What, Why and How?"
Builder 3&2 Volume 01 – "Construction manual for building structures"
D.M. Roy, G.M. Idorn, "Concrete Microstructure" Strategic Highway Research Program, National Research Council, Washington, DC 1993.
IS 456:2000, Indian Standard-"Plain & Reinforced concrete-Code of Practice", 4th revision, page 27.

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