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Study on the Effectiveness of Various Curing Methods on the Properties of Concrete

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***Abstract*— Concrete is the most widely used man-made material in the world. Concrete derives its strength by the hydration of cement particles. The Curing allows continuous hydration of cement and consequently continuous gain in the strength. Scarcity of potable water increases day by day. The use of membrane curing compound is very important from the point view that water resources are getting valuable every day. The advancements in the construction and chemical industry have paved way for the development of the new curing techniques and construction chemicals such as Membrane curing compounds, Self-curing agents, Water proofing compounds etc. This study considered the effectiveness of various curing methods on the properties of concrete. Curing has a strong influence on the properties of hardened concrete. The parameter of the study includes various curing period and various curing methods [Dry curing, Immersion technique, Liquid membrane curing compound, water proofing compound].**

Keywords*— *Curing methods, Liquid membrane curing compound, Water proofing compound, Hardened properties

I. INTRODUCTION

Curing is the maintenance of a satisfactory moisture content and temperature in concrete for a period of time immediately following placing and finishing so that the desired properties may develop. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Curing has a strong influence on the properties of hardened concrete; proper curing will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking Curing techniques and curing duration significantly affects curing efficiency. Membrane-forming compounds used in situations when concrete works are carried out in the places where there is acute shortage of water and the application of water for water curing is not possible for reasons of economy. They are the most practical and most widely used method for curing not only freshly placed concrete but also for extending curing of concrete after removal of forms or after initial moist curing.

II. CURING METHODS

After casting, the specimens were allowed to set for 24hours. The specimens were then removed from the moulds and applying various types of curing methods. The concrete specimens were cured using four different techniques.

The curing techniques that were applied are:

- Dry Curing: It involved no form of active curing by just exposing the specimens to ambient air in the Laboratory.
- Water immersion Curing: This involved the submersion of the concrete specimens in water.
    1. 7 days immersed in water followed by dry curing
    2. 14 days immersed in water followed by dry curing
    3. 28 days immersed in water
- Liquid membrane curing compound: The specimens were covered with at least two layers of membrane curing compound to prevent moisture movement from the concrete specimens.
    1. Acrylic resin based curing compound

Fig 1 Cubes covered with acrylic resin based curing compounds

2. Wax based curing compound

Fig 2 Cubes covered with wax based curing compounds

- Water proofing compound: The specimens were covered with at least two layers of water proofing compound to prevent moisture movement from the concrete specimens.

Fig 3 Cubes covered with water proofing compounds

III. EXPERIMENTAL INVESTIGATIONS

A. *Material Properties*

i) Cement: Portland slag cement was used. Laboratory test were conducted to determine the properties of cement. The properties of the cement used are listed in Table 1.

Table1. Properties of Portland slag cement

Test	Results	Correct value
Fineness	1%	Less than 10%
Specific gravity	3.09	3.15

ii) Fine aggregate: The fine aggregate used for the study was manufactured sand which was free from deleterious materials like clay, silt content etc. Laboratory tests were conducted to determine different physical properties as per is 383 (part III)-1970. Sieve analysis was done to determine the grain size distribution of fine aggregate. The properties of fine aggregate are shown in table 2.

Table 2 Properties of fine aggregate

Test	Result
Specific gravity	2.65
Grading zone	I

iii) Coarse aggregate: The coarse aggregate used for the work is 20mm and 12.5mm size which was free from deleterious materials like clay, silt content etc. Laboratory tests were conducted on coarse aggregate to determine the different physical properties as per IS 383 (part III)-1970. The properties of coarse aggregates are shown in table 3.

Table 3 Properties of coarse aggregate.

Test	Result	
	20mm	12.5mm
Specific gravity	2.78	2.8

iv) Mixing water: Clean drinking water available was used for casting as well as curing of the test specimens.

v)Superplasticizer: The superplasticizer used was based on modified polycarboxylic ether. . This increases the workability of concrete drastically and also facilitates excellent retention of workability. It consists of a carboxylic ether polymer with long side chains. The properties of superplasticizer are shown in table 4.

Table 4 properties of superplasticizer

Aspect	Light brown liquid
Relative Density	1.08 ± 0.01 at 25°C
pH	>6
Chloride ion content	< 0.2%

vi) Acrylic resin based curing compound: Acrylic resin based curing compound is a non-degrading, membrane forming liquid based on specially formulated acrylic resin suitable for curing newly placed or freshly deshuttered concrete. Properties of Acrylic resin based curing compound are shown in table 5.

Table 5 Properties of Acrylic resin based curing compound

Appearance	: Clear/white liquid
Specific gravity Clear	: 0.82 ± 0.01 at 25° C
White	: 0.855 ±0.01 at 25° C
Flash point	: 30°C
Dry film appearance	:Clear or white
Loss of Water (ASTM C156)	: < 0.55 kg /m2
Drying time (ASTM C309)	: 45 minuts at 25°C

vii) Wax based curing compound: Wax based curing compound is a solvent free; membrane forming wax emulsion, suitable for curing newly placed or freshly deshuttered concrete assists in the retention of water during hydration. Properties of Wax based curing compound are shown in table 6.

Table 6 Properties of Wax based curing compound

Aspect	White liquid
Relative density	1 ± 0.05 @ 25° C
Dry film appearance	white solar reflective
Loss of Water (ASTM C156)	< 0.55 kg /m^2
Day light reflectance(ASTM E1347)	> 60%
Drying time	Less than 3 Hours

viii) Water proofing compound: Water proofing compound is based on modified styrene butadiene latex supplied as a ready to use bonding agent in liquid consistency. It bonds strongly to old & new concrete and to plasters. It reduces shrinkage, prevents cracking, dust pick up & improves abrasion resistance. Properties of Water proofing compound are shown in table 7

Table 7 Properties of water proofing compound

Nature	Milky white, translucent, free flowing liquid
Type	SBR Latex- (Styrene Butadine Rubber latex)
Total solids % by mass @ 1050C	38 + 1
pH value	7.7

B. Mix proportion : The final proportion was 1:1.8:3.1 (cement: fine aggregate: coarse aggregate) with w/c of 0.39.

IV. PROPERTIES OF CONCRETE

A. Fresh properties of concrete

i) Workability of concrete: It is the property of concrete which determines the amount of useful internal work necessary to produce full compaction. Slump test was done to measure the workability of concrete. Slump test was done to measure the workability of concrete.

B. Mechanical properties of hardened concrete

ii) Compressive strength: The compressive strength test was carried out on cubical specimen of size 150mm in a compression testing machine of capacity 2000kN, as per IS 516:1959 specification. Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. For the experiment, cube size of 150 x 150 x 150mm was adopted. Tests were conducted for concrete with various curing methods.

Fig 4 Determination of compressive strength of cube

iii) Flexural strength: For finding flexural strength of concrete beams of size 150x150x700mm were made and applied various curing methods for specified time period. Hand compaction technique was adopted. Specimens were casted and tested on the 28th day.

iv) Split tensile strength: For finding split tensile strength of concrete cylinders of size 150x300mm were made and applied various curing methods for specified time period. Hand compaction technique was adopted. Specimens were casted and tested on the 28th day.

Fig 5 Determination of split tensile strength of cylinder

V. RESULTS AND DISCUSSION

A. Compressive strength of hardened concrete

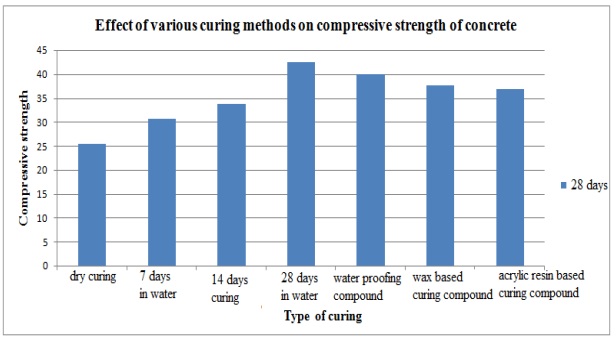

Fig 6 Effect of various curing methods on compressive strength

It is clear that concrete is not cured and is allowed to dry in air it attained only 66% of compressive strength after 28 days. Concrete cured at 7 days, 14 days in water it will gain 80% and 88% compressive strength after 28 days .28 days water curing and water proofing compound will gain maximum compressive strength. Use of wax based curing compound and acrylic resin based curing compound showed 99% and 96% compressive strength after 28 days.

B. Flexural strength of hardened concrete

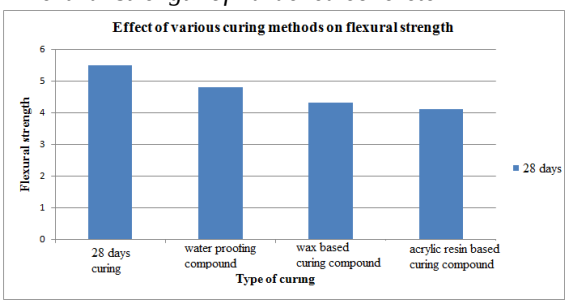

Fig 7 Effect of various curing methods on flexural strength

As compared with normal water curing, concrete with waterproofing compound showed 12%, concrete with wax based curing compound showed 21%, and concrete with acrylic resin based curing compound showed 26 % decrease in flexural strength.

C. Splitting tensile strength of hardened concrete

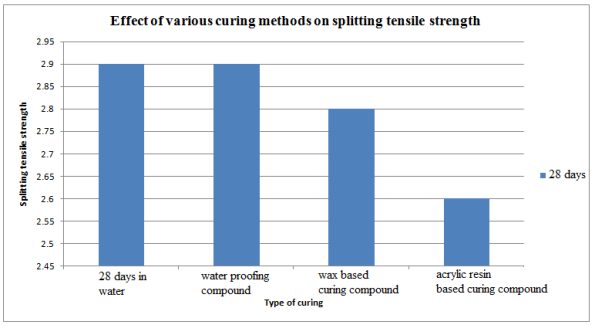

Fig 8 Effect of various curing methods on splitting tensile strength

As compared with normal water curing, concrete with waterproofing compound showed 7%, concrete with wax based curing compound showed 10%, and concrete with acrylic resin based curing compound showed 16% decrease in splitting tensile strength.

VI. CONCLUSION

Conventional water curing is the most efficient method of curing as compared to Membrane curing, 7days, 14days water curing and dry air curing methods. Using wax based curing compound and acrylic resin based curing compound can achieve 99% and 96% of compressive strength compared to Conventional Curing method. Membrane curing compounds are most practical and widely used method it is most suitable in water scarce area.

Compare to normal water curing, concrete with water curing water proofing compound attained maximum compressive strength. Compared to normal water curing, concrete with waterproofing compound showed 12%, concrete with wax based curing compound showed 21%, and concrete with acrylic resin based curing compound showed 26 % decrease in flexural strength. Compared with normal water curing, concrete with waterproofing compound showed 7%, concrete with wax based curing compound showed 10%, and concrete with acrylic resin based curing compound showed 16% decrease in splitting tensile strength. The study demonstrates that the method and duration of curing greatly affects the strength characteristic of concrete. The data developed in this study indicate that curing compounds could be utilized in situations where curing with water is difficult. Among the two curing compounds investigated, wax based curing compound performed better than acrylic resin based curing compound.

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