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Study of Different Methods of Curing of Concrete & Curing Periods

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Abstract: ***The advancements in the construction and chemical industry have paved way for the development of the new curing techniques and construction chemicals .curing is essential if concrete is to perform the intended function over the design life of the structure while excessive curing time may lead to the escalation of the construction cost of the project and unnecessary delays. 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. The behaviour of different methods of curing to achieve higher strength in concrete is studied.***
Keywords: curing methods, strength.

I. INTRODUCTION

Curing can be described as the process of maintaining a satisfactory moisture content and a favourable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the desired properties are developed to a sufficient degree to meet the requirement of service. Curing of concrete plays a major role in developing the microstructure & pore structure of concrete. Uniform temperature should be maintained throughout the concrete depth to avoid thermal shrinkage cracks. If curing is neglected in the early period of hydration, the quality of concrete will experience a sort of irreparable loss. An efficient curing in the early period of hydration can be compared to a good and wholesome feeding given to a new born baby.

II. METHODS OF CURING CONCRETE

There are various methods of curing. The adoption of a particular method will depend upon the nature of work & the climatic conditions. The following methods of curing of concrete are generally adopted:

A. Water Curing

This method is by far the best method of curing as it satisfies all the requirements of curing, namely, promotion of hydration, elimination of shrinkage and absorption of the heat of hydration. It is pointed out that even if the membrane method is adopted, it is desirable that a certain extent of water curing is done before the concrete is covered with membranes. Water curing can be done in the following ways:

1) *Ponding & Immersion:* On flat surfaces, such as pavements and floors, concrete can be cured by ponding. Ponding is an ideal method for preventing loss of moisture from the concrete; it is also effective for maintaining a uniform temperature in the concrete. The curing water should not be more than about 11°C (20°F) cooler than the concrete to prevent thermal stresses that could result in cracking. Since ponding requires considerable labor and supervision, the method is generally used only for small jobs. The most thorough method of curing with water consists of total immersion of the finished concrete element. This method is commonly used in the laboratory for curing concrete test specimens. The precast concrete items are normally immersed in curing tanks for a certain duration. Pavement slabs, roof slab etc. are covered under water by making small ponds
2) *Fogging & Spraying:* Fogging and sprinkling with water are excellent methods of curing when the ambient temperature is well above freezing and the humidity is low. Fogging is applied to minimize plastic shrinkage cracking until finishing operations are complete. Vertical retaining wall or plastered surfaces or concrete columns etc. are cured by spraying water.
3) *Wet covering:* Fabric coverings saturated with water, such as burlap, cotton mats, rugs, or other moisture-retaining fabrics, are commonly used for curing. In some cases, wet coverings such as wet gunny bags, hessian cloth, jute matting, straw etc., are wrapped to vertical surface for keeping the concrete wet. For horizontal surfaces saw dust, earth or sand are used as wet covering to keep the concrete in wet condition for a longer time so that the concrete is not unduly dried to prevent hydration.

B. Membrane Curing

This method of curing is to cover the wetted concrete surface by a layer of water proof material, which is kept in contact with the concrete surface of seven days. This method of curing is termed as membrane curing. Sometimes, concrete works are carried out in places where there is acute shortage of water. It has been pointed out earlier that curing does not mean only application of water, it means also creation of conditions for promotion of uninterrupted & progressive hydration. A membrane will prevent the evaporation of water from the concrete. The membrane can either in solid or liquid form. They are also known as sealing compounds. Bituminised water proof papers, wax emulsions, bitumen emulsions and plastic films are the common types of membrane used. Whenever bitumen is applied over the surface for curing, it should be only after 24 house curing with gunny bags. The surface is allowed to dry out so that loose water is not visible and then the liquid asphalt sprayed throughout. The moisture in the concrete is thus preserved. It is quite enough for curing. This method is a good method of maintaining a satisfactory state of wetness in the body of concrete to promote continuous hydration when original water/cement ratio used is not less than 0.5. To achieve best results, membrane is applied after one or two days of actual wet curing.

C. Application of Heat

The development of strength of concrete is a function of not only time but also that of temperature. When concrete is subjected to higher temperature it accelerates the hydration process resulting in faster development of strength. Concrete cannot be subjected to dry heat to accelerate the hydration process as the presence of moisture is also an essential requisite. Therefore, subjecting the concrete to higher temperature and maintaining the required wetness can be achieved by subjecting the concrete to steam curing. A faster attainment of strength will contribute too many other advantages mentioned below. The exposure of concrete to higher temperature is done in the following manner:

1) *Steam Curing at Ordinary Pressure:* Steam curing is advantageous where early strength gain in concrete is important or where additional heat is required to accomplish hydration, as in cold weather. This method of curing is often adopted for prefabricated concrete elements. Application of steam curing to in situ construction will be a difficult task. Steam curing at ordinary pressure is applied mostly on prefabricated elements stored in a chamber. The chamber should be big enough to hold a day's production. The steam may be applied either continuously or intermittently. An accelerated hydration takes place at this higher temperature and the concrete products attain the 28 days strength of normal concrete in about 3 days. In India, steam curing is often adopted for precast elements, specially pre-stressed concrete sleepers. Concrete sleepers are being introduced on the entire Indian railway. For rapid development of strength, they use special type of cement namely OPC 53 S and also subject the sleepers to steam curing.
2) *Steam Curing at High Pressure:* In the steam curing at atmospheric pressure, the temperature of the steam is naturally below 100^C. The steam will get converted into water, thus it can be called in a way, as hot water curing. This is done in an open atmosphere. The high pressure steam cured concrete develops in one day, or less the strength as the 28 days strength of normally cured concrete. The strength developed does not show retrogression. In high pressure steam curing, concrete is subjected to a maximum temperature of about 175^C which corresponds to a steam pressure of about 8.5 kg/sq.cm. When the concrete is subjected to high pressure steam curing, it is invariably made by admixing with 20 to 30 percent of pozzolanic material such as crushed stone dust. It is also observed that improvement in durability is more for the concrete made with higher water/cement ratio, than the concrete made with low water/cement ratio. The higher rate of development of strength is attributed to the higher temperature to which a concrete is subjected. One of the advantage derived from high pressure steam curing process exhibits higher resistance to sulphate attack, freezing and thawing action and chemical action. It also show less efflorescence.
3) *Curing by Infra-Red Radiation:* Curing of concrete by infra-red radiation has been practised in very cold climatic regions in Russia. It is claimed that much more rapid gain of strength can be obtained than with steam curing and that rapid initial temperature does not cause a decrease in the ultimate strength as in the case of steam curing at ordinary pressure. The system is very often adopted for the curing of hollow concrete products. The normal operative temperature is kept at about 90^C.
4) *Electrical Curing:* This is another method of curing concrete, which is applicable mostly to very cold climatic regions is the use of electricity. This method is not likely to find much application in ordinary climate owing to economic reasons. Concrete can be cured electrically by passing an alternating current trough the concrete itself between two electrodes either buried in or applied to the surface of the concrete. Care must be taken to prevent the moisture from going out leaving the concrete completely dry.

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D. Miscellaneous Methods of Curing

In this method of curing calcium chloride is used either as a surface coating or as an admixture. It has been used satisfactorily as a curing medium. Both these methods are based on the fact that calcium chloride being a salt shows affinity for moisture. The salt not only absorbs moisture from atmosphere but also retains it at the surface. This moisture held at the surface prevents the mixing water from evaporation and thereby keeps the concrete wet for a long time to promote hydration. Formwork prevents escaping of moisture from the concrete, particularly, in the case of beams and columns. Keeping the form work intact and sealing the joint with wax or any other sealing compound prevents the evaporation of moisture from the concrete. This procedure of promoting hydration can be considered as one of the miscellaneous methods of curing.

1) *Hot Weather Curing:* Hot weather leads to more rapid drying of concrete, protection and curing are critical. Water curing, if used should be continuous to avoid volume changes due to alternate wetting and drying. The need for adequate continuous curing is greatest during the first few days after placement of concrete in hot weather. During hot weather, provided favourable moisture conditions are continuously maintained, concrete may attain a high degree of maturity in a very short time.
2) *Cold Weather Curing:* Concrete exposed to cold weather is not likely to dry at an undesirable rate; particular attention should be given to maintaining satisfactory moisture in concrete. Concrete should be protected from freezing at least until it develops a compressive strength of 3.4Mpa; non air concrete should never be allowed to freeze and thaw in a saturated condition. Air entrained concrete should not be allowed to freeze and thaw in a saturated condition before developing a compressive strength of 24 Mpa.These factors should be considered especially for concrete late in the fall.

E. Internal Moist Curing

Internal moist curing refers to methods of providing moisture from within the concrete as opposed to outside the concrete. This water should not affect the initial water to cement ratio of the fresh concrete. Lightweight, fine aggregate or absorbent polymer particles with an ability to retain a significant amount of water may provide additional moisture for concretes prone to self-desiccation. When more complete hydration is needed for concretes with low water to cement ratios (around 0.30 or less), 60 kg/m3 to 180 kg/m3 (100 lb/yd3 to 300 lb/yd3) of saturated lightweight fine aggregate can provide additional moisture to extend hydration, resulting in increased strength and durability. All of the fine aggregate in a mixture can be replaced with saturated lightweight fine aggregate to maximize internal moist curing. Internal moist curing must be accompanied by external curing methods.

III. CURING PERIODS & TEMPERATURE

The duration of curing of concrete depends on the grade & type of cement, mix proportion, desired concrete strength, shape & size of the concrete members and environmental and exposure condition. The duration may varies from a few days to a month. The period of time that concrete should be protected from freezing, abnormally high temperatures, and against loss of moisture depends upon a number of factors: the type of cementing materials used; mixture proportions; required strength, size and shape of the concrete member; ambient weather; and future exposure conditions. The curing period may be 3 weeks or longer for lean concrete mixtures used in massive structures such as dams; conversely, it may be only a few days for rich mixes, especially if Type III cement is used.

For concrete slabs on ground (floors, pavements, canal linings, parking lots, driveways, sidewalks) and for structural concrete (cast-in-place walls, columns, slabs, beams, small footings, piers, retaining walls, bridge decks), the length of the curing period for ambient temperatures above 5°C (40°F) should be a minimum of 7 days; additional time may be needed to attain 70% of the specified compressive or flexural strength. When the daily mean ambient temperature is 5°C (40°F) or lower A higher curing temperature provides earlier strength gain in concrete than a lower temperature but it may decrease 28-day strength as shown in Fig. 12-11. If strength tests are made to establish the time when curing can cease or forms can be removed, representative concrete test cylinders or beams should be fabricated in the field, kept adjacent to the structure or pavement they represent, and cured by the same methods. During cold weather, additional heat is often required to maintain favourable curing temperatures of 10°C to 20°C (50°F to 70°F).

Regarding how long to cure, it is again difficult to set a limit. Since all the desirable properties of concrete are improved by curing, the curing period should be as long as practical. For general guidance, concrete must be cured till it attains about 70% of specified strength. At lower temperature curing period must be increased. Since the rate of hydration is influenced by cement composition

and fineness, the curing period should be prolonged for concretes made with cements of slow strength gain characteristics. Pozzolanic cement or concrete admixed with pozzolanic material is required to be cured for longer duration. Mass concrete, heavy footings, large piers, abutments, should be cured for at least 2 weeks

IV. CONCLUSIONS

In this research paper we are studying in details about the different methods of curing concrete. Here are some conclusions after studying :-

A. The use of the following curing methods: immersion in lime water; covering with wet rug; covering with plastic sheets; and immersion in water, should be limited to the 28-day curing period. After 28 days curing period, the increase in compressive strength was not significant except for concrete cubes air-dried.
B. Conventional water curing is the most efficient method of curing as compared to Membrane curing, Self-curing, Wrapped curing and Dry air curing methods.
C. Use of curing compounds resulted in strength up to 85 to 90 % by ponding method.
D. The Immersion curing and Wet gunny bag curing attained an average compressive strength.
E. Concrete subjected to steam curing exhibits a slightly higher drying shrinkage and moisture movement.
F. Where there is acute shortage of water, membrane curing is more useful than water curing.
G. High pressure steam curing exhibits higher strength and durability particularly in the case of cement containing a proportionately higher amount of C3S.

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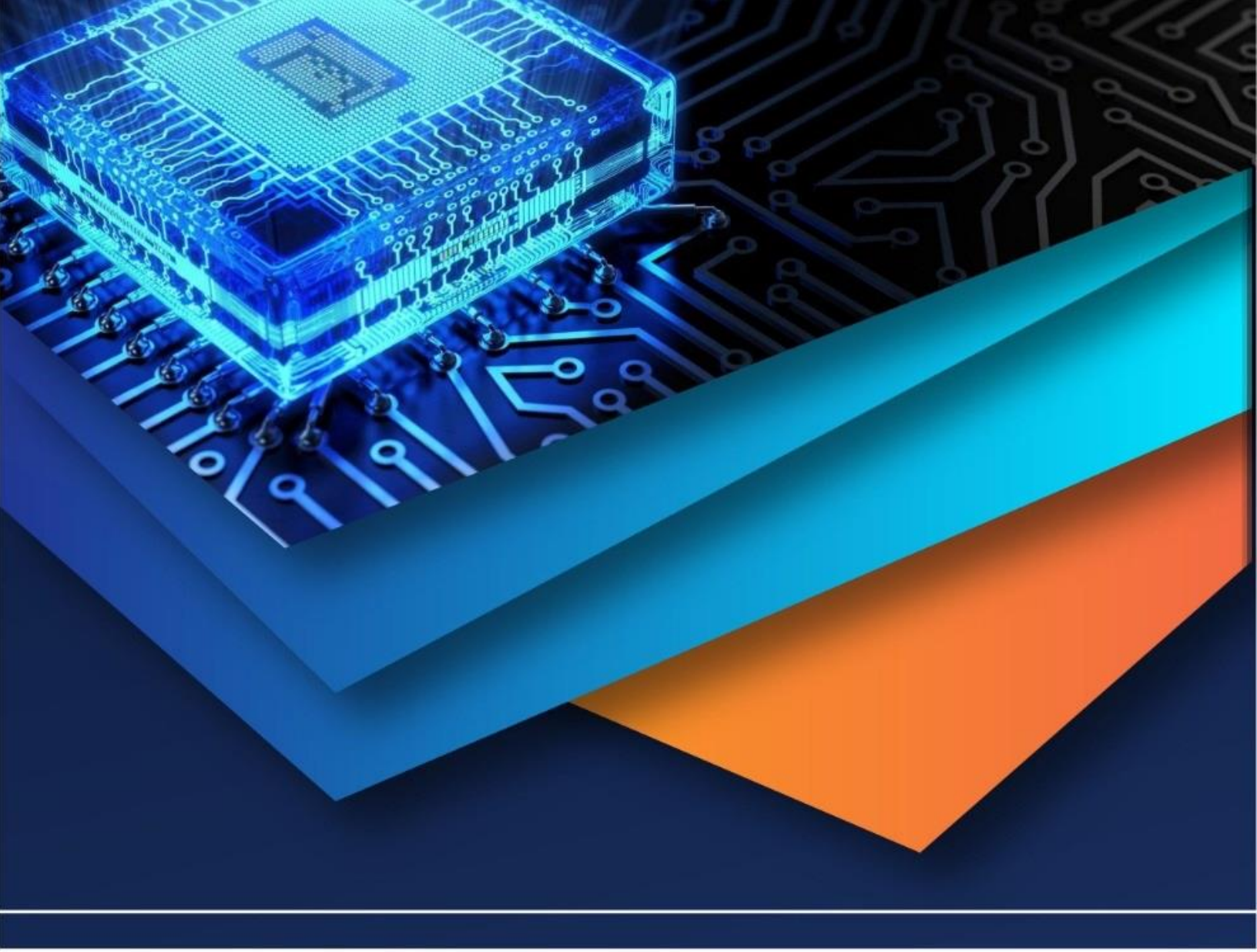

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