

# Importance of Curing in Self-Healing Concrete: A Study

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## Abstract

As concrete is the most commonly used construction material in the world, which actually is one of those very smart materials which incorporates the ability of repairing itself from damages caused by mechanical usages or may be due to environment related factors. In concrete this self-repairing/ healing process is related to those biological systems which heal themselves after being wounded. The damages such as cracks etc., when studied deeply at microscopic levels shows the various changes that occurs in its properties such as thermal, electrical and acoustical properties even leading to the complete failure of the structure. Any material including concrete is called self-healing only when, it has the ability to heal itself without human intervention and such can be achieved by using polymerization catalysts. In studying such cases, the term thickness also plays an important role, such as if the wall of any structure studied is constructed excessively thick, then it may not fracture and if the studied wall is constructed excessively thin, it may rupture as well. So, in order to attain maximum possible strength in concrete, the process of curing is adopted which protects it against the loss of moisture needed for the hydration process and also helping it to be in its optimum temperature range as recommended, as curing is also responsible for increasing strength and decreasing the permeability of the concrete hence reducing thermal and plastic cracks. The main objective of the study is to know the importance of curing in Self-Healing bacterial concrete. The major findings and fruitful suggestions have been given in full paper.

**Keywords:** Bacterial Concrete, Crack-Healing, Permeability, Micro-organisms, Hydration.

## Introduction

Concrete is a building material most commonly used for construction purposes in the whole world but it is also very prone to certain damages which may happens due to a number of reasons such as mechanical usage over time, or sometimes nature related factors like weathering, floods and earthquakes or may be due to human activities. AS it is very common known fact that the concrete also

has the tendency to expand and shrink with the temperature variations, which causes cracks and such cracks most of the times are generally related to the overall durability of the structure because these cracks also works as the pathways for the moisture to travel into the structure even up to the reinforcement resulting in corrosion of the steel bars reducing the service life of the structure. So to prevent such situations to arise, a very important practice of curing is done in the initial stages to attain the maximum possible strength. In structures where bacterial concrete is used, curing also plays an important role because, the bacteria's or micro-organisms used in concrete while curing reacts with the water/moisture, resulting in the formation of calcium carbonate or limestone crystals, hence filling the left over voids, so that more strength as compared to regular concrete can be achieved. Generally, curing is all about keeping the concrete moisturized till the process of hydration is completed. It is started at very initial stage just after the removal of the shuttering and must be practiced for a reasonable interval of time. The most important thing to make sure in the curing is the un-disturbed hydration of the RC and PCC, after the placement and finishing of the concrete section in its desired place. Maintaining uniform temperature is also to be taken care of throughout the depth of the concrete section to avoid thermal expansions and shrinkages.

## Objective of Study

Specific objectives of present study are:

- To study the elements directly related to self-healing mechanism in concrete.
- To study factors related to curing in concrete.
- To make suggestions on the basis of findings.

## Curing Methods

**Water Curing:** Water curing is the most common and economical method of curing of concrete. In fact, it is one of the best curing techniques which satisfies all the needs such as proper hydration, elimination of shrinkage and removal of hydration heat.

### Types of Water Curing

**Ponding Method:** This method is mainly used on surfaces which are usually flat, such as floors and pavements. This method of curing is known as the most suited method for preventing the loss of moisture from the concrete by maintaining constant temperature effectively but there are certain limitations as well, i.e. the temperature difference between curing water and the concrete must not exceed 11 Degrees (Celsius) to prevent cracking due to induced thermal stresses.

**Fogging Method:** Curing by fogging is a very special method generally used in places where the ambient temperature is above the freezing point with very low humidity. This method is adopted to minimize the cracking due to plastic shrinkage until maximum strength is attained and all finishing related operations are over.

**Spraying Method:** This method includes spraying water on vertical surfaces to maintain the required moisture of the concrete section such as on vertical retaining walls and concrete columns etc.

**Wet Covering Method:** This type of curing method involves fabric covering such as rugs, cotton mats or other materials which can retain moisture within themselves like gunny bags and jute matings etc. In this technique such water retaining materials are wrapped to vertical surfaces, For horizontal surfaces sand, earth or saw dust are used as wet coverings for keeping the surface moisturized for longer durations.

### Membrane Curing

Membrane curing is a special method in of curing in which the surface is the surface to be cured is covered with the layers of water proof materials in the form of membranes on the concrete of at least 7 days, This technique is generally used in places

where there is a shortage of water, as these membranes also prevents evaporation of water from the surface of the concrete section. Such membranes can be in both solid as well as liquid forms known as sealing compounds. Some common membrane materials used are wax and bitumen emulsions, bituminizes water proof papers and plastic films.

**Curing by Heating:** Strength in concrete is not only achieved with time but it is also related to temperature as well, such as concrete exposed to higher temperature develops strength faster as compared to concrete exposed to lower temperature. Due to the accelerated hydration speed, but there are certain limitations as well i.e. the strength in concrete cannot be directly related to dry heat because presence of moisture is again an important aspect for gaining strength. Therefore, steam curing technique is adopted through which required heat and moisture levels can be maintained. Steam curing is done in a number of ways some of which are Normal Pressure Steam Curing, High Pressure Steam Curing and Curing by Infrared Radiations.

**Internal Curing:** It is a method in which moisture from within the concrete is used for curing without affecting the fresh concrete water to cement ratio, In its aggregates having properties of retaining moisture are used which provides significant amount of moisture to the concrete when more hydration is needed in concrete with low water to cement ratio i.e.  $> 0.30$  per 60 kg/m<sup>3</sup> to 80 kg/m<sup>3</sup> of saturated aggregates can provide extra needed moisture for hydration to gain appropriate strength and durability. These fine aggregates used for making concrete can be replaced with saturated lightweight fine aggregates to maximize internal curing

**Need of Internal Curing:** As the mineral admixtures present starts reacting in the blended cement, the need for extra moisture arises, as this extra requirement is much higher than that as present in an ordinary concrete and when available moisture contents decreases due to the depreciation of the capillary porosity. During hydration, when chemical shrinkage occurs, the empty voids are formed in the cement paste resulting in the decreased internal relative humidity which can further cause cracking due to shrinkage. These

empty voids formed during self-desiccation induce shrinkage stresses and also influences the kinetic of cement hydration process, limiting the overall process of hydration.

## Conclusions

- Curing with Wet-rags and Plastic Sheets should be done until the 28<sup>th</sup> day, Afterwards, the gain in compressive strength becomes in-significant.
- Water curing method comes up as the most efficient curing method.
- Curing with Wet-Gunny bags only results in an average gain in compressive strength.
- Higher rate of Drying Shrinkage is observed in curing with heating technique
- Membrane curing is the most useful curing technique at places where there is shortage of water.

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