

## Effect of Carbon-Dioxide Curing on Concrete

Vijay Kumar Y M<sup>1</sup>, Kavan M R<sup>2</sup>, Keerthi Gowda<sup>3</sup> & Chandre Gowda C<sup>4</sup>

<sup>1,2</sup>Department of Civil Engineering, AIT, Chikamagalur, VTU Chikamagalur, India

<sup>3</sup>Department PG Studies, VTU PG Center, Mysuru, India

<sup>4</sup>Centre for Innovation, Incubation, Research & Consultancy, Jyothy Institute of Technology, VTU, Bengaluru, India

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**Abstract** — The study is carried to evaluate the carbon dioxide cured concrete over traditional curing of concrete. Two mix designs M25 and M30 are considered for curing. Different samples were prepared and cured for both the cases. The periodical observation is done to find the compressive strength at 7 days to 28 days for normal cured; 2 hours to 4 hours for CO<sub>2</sub> cured. The results show that CO<sub>2</sub> cured concrete achieves 76.28% target strength within 2 hours and normal cured 75.8 % target strength in 7 days for M25. For both M25 and M30 grade concrete with water curing achieved compressive strength more than the target strength.

**Keywords-** Curing; Carbon dioxide; hydration; compressive strength;

### I. INTRODUCTION

The concrete is a material made up of combination with cement, water, aggregates and other constituents. The strength characteristics of concrete have many uses in infrastructural development. To achieve the desired strength, curing plays an important role [1]. Numerous methods have been adopted in curing. The curing is necessary if concrete is to achieve its strength and durability [1]. Curing is done by different methods, appropriately decided on the basis of construction technique and condition of site. The requirement for sufficient curing has not been emphasized technically. In general curing increases durability, stability of the volume, corresponding strength, reduced permeability, resistance to abrasion and freezing thawing. Curing of concrete intends to achieve hydration of cement, controlling the setting time and humidity conditions during casting. Curing is a process of regulating the rate and extent of moisture loss. In modern constructions, the timely completion of the project is rare. So many new techniques have been used in casting and curing of concrete. In precast concrete fabrication the acceleration method is adopted and which is proved to be beneficial. The steam curing and CO<sub>2</sub> curing are other latest methods which are adopted for curing within shorter duration [5] [7] of 2 to 24 hours [9].

The carbon dioxide (CO<sub>2</sub>) in curing, enters into concrete and reacts with cement to form calcium carbonate and other products [8], known as carbonation of concrete. Determining advantages of as-captured or regenerated CO<sub>2</sub> is difficult and decisive to greenhouse alleviation. Amongst curing, use of the CO<sub>2</sub> in curing is a significant technology developed and adopted for carbonated concrete products. In carbonation CO<sub>2</sub> reacts with water to form calcium hydroxide (Ca(OH)<sub>2</sub>). Calcium silicate and aluminates with CO<sub>2</sub> form calcium carbonate and hydrates. Carbonation shows improved strength and durability of cement products. Carbonation may not be useful in non-reinforced cement products [2]. CO<sub>2</sub> is the most dominant greenhouse gas, so the present study focuses on utilization of CO<sub>2</sub> emissions and use it in curing process. The concrete cured by CO<sub>2</sub> does not hamper the properties of the concrete in comparison with the conventionally cured concrete [3].

The curing carbonation procedure is different from weathering carbonation that in nature occurs within hardened concrete. Weathering carbonation is well acknowledged and has been widely investigated [4]. In weathering carbonation, hydration takes place first when cement particle come in contact with water followed by natural carbonation.

Weathering carbonation of concrete is a sluggish progression; and become an apprehension in reinforced structures. While the carbonation decreases pH of concrete trigger the corrosion in reinforcements [4]. The CO<sub>2</sub> is diffused into the fresh concrete under low pressure and transform the gaseous CO<sub>2</sub> into solid calcium carbonates (CaCO<sub>3</sub>) [6].

Since curing carbonation is an extremely exothermic reaction, concrete is hardened at a quicker rate than by steam curing at 75°C. The carbonation elements are mainly calcium carbonates and silica gel. For utilizing with no reinforcing steel, the carbonated concrete elements can amplify strength, durability and stable dimensions. They are suitable for concrete elements, such as blocks and cement boards. The mixture stiffness increases with increase in the sodium

hydroxide molarity [8]. Reduction of carbon foot prints by using CO<sub>2</sub> is very much appreciated [10]. So the evaluation of CO<sub>2</sub> cured concrete is attempted in the study.

## II. MATERIALS AND METHODS

In the study the properties of cement and aggregates are determined before its usage. The details regarding raw material, mix proportion, specimen preparation and curing are discussed in this section.

### A. Rawmaterial and mix proportion

The Ordinary Portland cement (OPC) of 43 grade is used in casting. The property of the cement is shown in table 1. Manufactured sand (Fineness Modulus 2.4) is used as fine aggregates and crushed stones are used as coarse aggregate. The properties of aggregates are shown in Table 2. In addition, Table 3 shows the details of mix proportion.

TABLE I. PROPERTIES OF CEMENT

Sl. No.	Parameter	Value
1	Specific Gravity	3.14
2	Fineness Modulus	5%
3	Normal Consistency	30%
4	Initial setting time	60 minutes
5	Final setting time	6 hours 45 minutes

TABLE II. PROPERTIES OF AGGREGATES

Sl. No.	Parameter	Value	
		Coarse aggregate	Fine aggregate
1	Specific Gravity	2.47	2.56
2	Water Absorption	3%	1.62%
3	Moisture Content	0%	0%

TABLE III. WEIGH BATCHING OF MIX PROPORTION

Sl. No.	Component	weight/volume (kg/m <sup>3</sup> )
1	Cement	445.58
2	Fine aggregate	632.52
3	Coarse aggregate	1192.70
4	Water	186

### B. Specimens and Curing

The concrete is mixed at room temperature with a pan mixer. The fine aggregates and cement are successively added to the mixer and stirred to get homogeneous mix. Later water is added and mixing process is completed. After mixing, the concrete mixture is casted into cube moulds of size of 150 mm (3 samples each). The concrete cubes are cured for 28 days to attain maximum strength. Curing helps in maintaining the moisture on the surface of sample; by dipping into the water tank for 28 days. The other cube specimens are also placed into air tight container for CO<sub>2</sub> curing. The CO<sub>2</sub> is allowed into

the container through the valve for about 2.5 hours and then the valve is closed for next 1.5 hours. Once the cubes are cured (total 4 hours), the characteristic strength is determined.

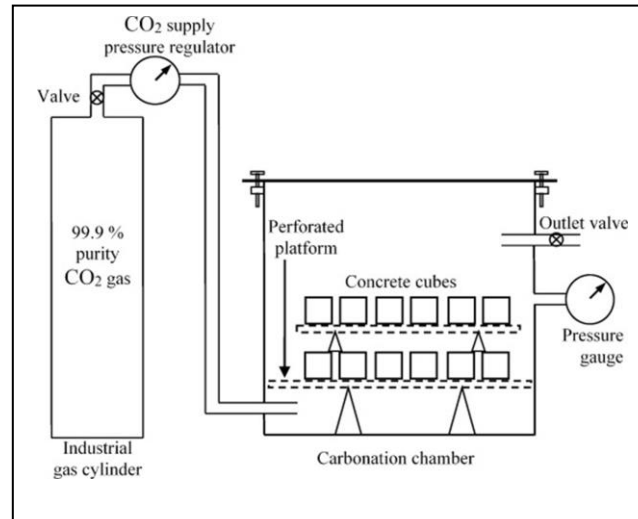


Figure 1. Schematic representation of CO<sub>2</sub> curing

### III. RESULTS AND DISCUSSION

The cubes under normal curing and CO<sub>2</sub> curing are tested for the strength at normal loading conditions through Universal testing machine (UTM) of 100 ton capacity. The results observed are represented in figure 2, figure 3 and figure 4. The compressive strength of M25 and M30 design concrete cubes cured in water for 7 and 28 days respectively are represented in figure 2. For M25 and M30 by regular curing method, strength of 31.02Mpa and 38.01Mpa are achieved after 28 days. Similarly, the strength of 22.90Mpa and 38.01Mpa is achieved for M30 grade concrete after 7 and 28 days by regular curing (figure 3). These results are attained due to intense curing of the cubes at regular provision, monitoring the continuous hydration process and formation of calcium silicate hydrate (CSH) gel.

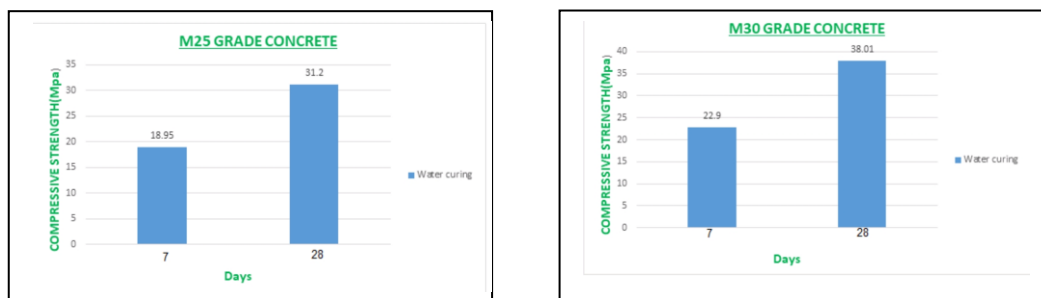


Figure 2. Characteric strength of concrete under normal curing methods for M25 and M30

The CO<sub>2</sub> curing time and strength of M25 and M30 grade concrete is represented in figure 3. From the result, it is evident that M25 concrete with CO<sub>2</sub> curing for 2 hours gives compressive strength of 76.28% (19.70Mpa) for and in normal curing for 7 days 75.8% (18.95Mpa) of the target strength is achieved, which is more required in rapid construction. This accelerated result is due to reaction between CO<sub>2</sub> with calcium hydroxide to produce calcium carbonate, hydrates of silica and aluminates. In the second case of M30, the compressive strength of 66.96% (20.90Mpa) is achieved after two hours of CO<sub>2</sub> curing and 76.33% (22.9Mpa) for 7days of regular curing. This difference is, due to the slow reaction of CO<sub>2</sub> in M30 and high pressure. But within 4 hours up to 82% (24.60Mpa) of strength is achieved for M30 for CO<sub>2</sub> cured specimens.

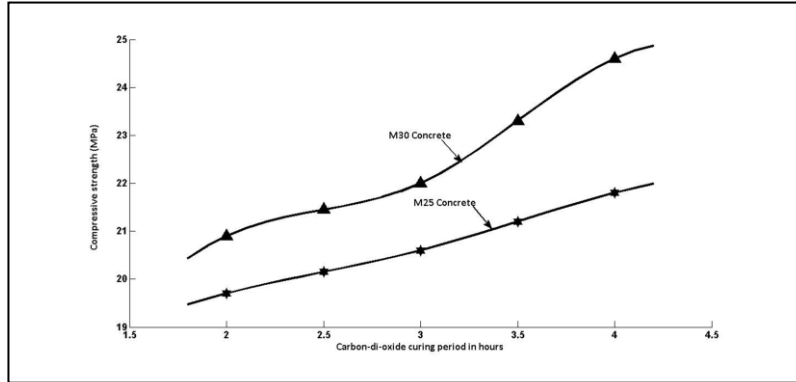


Figure 3. Strength V/S curing time of CO<sub>2</sub> concrete

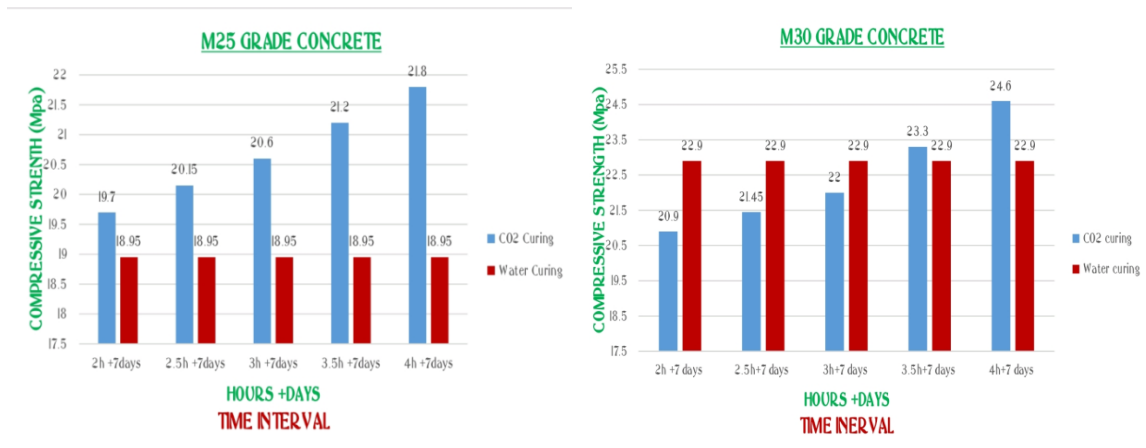


Figure 4. Comparison of compressive strength of M25 and M30 Concrete for Water curing and CO<sub>2</sub> curing

The figure 4 represents the comparison of samples, water cured for 7 days to 28 days and CO<sub>2</sub> cured for 2 hours and 4 hours. The gradual increase in the strength with respect to time can be observed in normal water cured samples, for both (M25 and M30).

**IV. CONCLUSIONS**

The effect of CO<sub>2</sub> curing over normal curing on compressive strength of concrete was carried. It was found that CO<sub>2</sub> cured specimens achieve strength at shorter duration, when compared to water cured specimens. From the experiment results the following conclusions are drawn.

- The CO<sub>2</sub> curing can be implemented for speedy constructions, where the time required to curing is less.
- The regular water curing can be used if achieving the target strength is important
- For low characteristic strength the CO<sub>2</sub> curing has more advantage
- With increasing the pressure and adding super plasticizer, can enhance the strength to curing time.
- The normal curing achieves higher compressive strength than the targeted value.

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