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EFFECT OF STRENGTH ON CARBONATION DEPTH

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ABSTRACT

Carbonation is main durability problem. Factors influencing carbonation such as curing regime, water/cement ratio, age of the concrete, type of aggregate, cement replacement material and strength are widely published. This paper will discusses on the effect of concrete strength on carbonation of concrete. OPC concrete cubes 100 mm^3 of design strength at 20, 30, 40, 50, 60, 70, and 80 N/mm^2 have been investigated. This covers a wide range of concrete strength used in industry. All concrete samples cured in water 28 days prior exposed into accelerated carbonation camber with 4% carbon dioxide concentration. Carbonation depth was measured for 5, 10, 15, 20, 25 and 30 weeks exposed. The results shown carbonation depth on strength and decreased as strength of concrete was increased.

INTRODUCTION

Hydrated concrete has tendency of reacting with carbon dioxide present in the atmosphere of forming carbonates, which lower alkaline nature of concrete. This process is known as carbonation. If continued unabated carbonation can destroy the passive film around embedded reinforcement increase the likelihood for subsequent corrosion of the steel. (Parrot, 1994)

Factors influencing carbonation such as curing regime, water/cement ratio, age of the concrete, type of aggregate, cement replacement material and strength are comprehensively complied by Parrot (1994). The progress of carbonation is greatly influenced by the relative humidity of the external environment and resulting moisture conditions of concrete and it is generally agreed that carbonation will only occur in humidity environments between 30 and 70% (Alexander and Wardlaw 1959). Other factors, in relation to the environment that may influence carbonation include (Verbeck 1958). the concentration of carbon dioxide, which may be locally high in industrial areas and environmental temperature.(Parrot, 1987)

This paper will discusses on the effect of grade (strength) on carbonation of concrete. The rate of carbonation was measured on concrete with regard of a wide range of comprehensive strength. All concrete samples exposed to accelerated carbonation camber with 4% carbonation concentration.

MATERIALS

Ordinary Portland Cement (OPC)

An Ordinary Portland Cement (OPC) complying with BS 12 (1978) was obtained in a large single bulk sample.

Aggregate

A natural sand and garvel complying with BS 882 (1985) were used. The coarse aggregate was in two single size fractions of 10mm and 20 mm, combined in the ratio of 1 to 2.All aggregates were dried in laboratary air until constant weight was achieve prior to their use.

Water

Tab water was used throughout to make the concretes.

MIX DESIGN

The design strength chosen for the concrete mixes at 28 day were 25, 35, 50, 60, 70 and 80 N/mm^2. This covered the full range of design strength used in practice. The water/cement ratio of mixed ranged from 0.34 to 0.79. The mix proportion, details are given in Table 1. All concrete was mixed in a $0.04m^3$ horizontal pan mixer. The concrete mixing procedure was carried out in accordance with BS 1881.

Table 1. Mix proportions

Concrete Mix Proportions, kg/m^3									
Design Strength N/mm^2	OPC	Total	Water	Aggregate			W/(C) Ratio	Slump	SP
				20mm	10mm	Sand			
25	235	235	185	800	400	770	0.79	100	-
35	285	285	185	800	400	730	0.65	75	-
50	355	355	185	800	400	670	0.52	75	-
60	410	410	185	800	400	625	0.45	75	-
70	475	475	185	800	400	570	0.39	75	-
80	545	545	185	800	400	515	0.34	75	0.7

CARBONATION TEST

Specimens Arrangement

The carbonation penetration tests were carried out on 100mm sided cubes. Prior to plain the cubes in the accelerated carbonation tanks, all specimens were normalised at least 14 days in the laboratory the ensure that the specimens were in a partially dry condition (at 20°C and 55% RH). Subsequently, all but one surface were coated with silence and sealing wax to ensure any ingress of carbon dioxide through the covered surfaces. The specimens were then placed in the carbon dioxide chamber.

Carbonation Apparatus

The measurement carbonation apparatus was developed by Dhir et al (1985). The rate carbonation of concrete I closely related to the relative humidity of surrounding of carbonation of concrete is closely related to the relative humidity of surrounding atmosphere. The system enables the carbon dioxide concentration inside the chambers to be varied from 0 to 24% by volume of air and the relative humidity from 25% to 95%. The concrete specimens were subjected to curing atmosphere of 4% carbon dioxide and 50% RH. One weeks exposure in curing enviroment is approximately equivalent to 15 months of normal atmospheric condition (Dhir et al, 1989).

Carbonation Depth

Carbonation depth was measured as recommended by RILEM (1984). The depth of carbonation was monitored at 5, 10, 20 and 30 weeks interval. Each time the test specimens were split perpendicular to the as-cast surface by inducing a tensile failure. The fractured surface was brushed to removed dust and loose particles then sprayed with a 1% solution of phenolphthalein. Three measurements were taken to the front from the exposed face and the average taken as depth of carbonation.

RESULTS AND DISCUSSIONS

The carbonation tests was carried fort 28 days water/air cured for samples of 25, 35, 50, 60, 70 and 80 N/mm^2 design strength respectively. The depth of carbonation was monitored at 5, 10, 15, 20 and 20 weeks interval. The test results obtained were tabulated in Table 2. The results shows the increase of carbonation depth with duration of exposure. This trend is consistent through all the mixes. The carbonation depth of water cured concrete is much higher for lower strength concretes. With any type of mix, the strength plays an important role in determining the depth of carbonation. The lower the design strength, the higher is the depth, which practically means that the penetration of carbon dioxide is more in lower grade concrete.

Table 2. Carbonation of 28 days water cured

Design Strength, N/mm^2	Exposure Time, Weeks			
	28 days curing			
	5	10	20	30
25	13	19	24	31
35	12	16	21	26
50	7	10	13	17
60	3	5	7	10
70	0	0	3	7
80	0	0	0	1

CONCLUSION

The result comfirmed the natural phenomenon that carbonation depth increases as the duration of exposure increases and also carbonation depth dependant strength of the concrete. The penetration of carbonation was found to be high in lower grades concrete for all design mixes. The results and agreement with another investigation reported by Diah et al (1997) but for exposed to natural exposure environment.

The improvement due to both the effects on microstructure and pore fluid chemistry of concrete (Richardson 1985). In terms of concrete microstructure the increased cement content and reduced water/cement ration associated with the increased in strength, influences the capillary continuity (Kreijger 1990), which increase significantly beyond water/cement ratio of 0.5. (Bandyopahdyah and Swamy,1975).

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