Non Uniform Corrosion of Carbon Cure RC Beam and Conventional RC Beam

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Abstract - *Carbon dioxide is one of the major gas which causes greenhouse effect. One of the main key factor is to reduce global warming is to decrease carbon dioxide emissions. One of the beneficial process to reduce carbon dioxide is to inject carbon dioxide into concrete blocks and Reinforced Concrete (RC) structures during the mixing cycle. The gas was absorbed into concrete to form thermodynamically stable carbonate reaction products distributed throughout the concrete matrix. The corrosion initiation time was taken as a comparative study for conventional RC beam and carbon cure RC beam. For seven days ,the corrosion initiation time was compared with carbon cure RC structure and conventional concrete .It was observed that corrosion spots were seen on second day for carbon cure RC beam where as conventional concrete corrosion spots were seen on first day.*

Key Words: **Carbon cure RC beam, Green house, Global warming, Corrosion spots, Carbon emissions,**

1.INTRODUCTION

Carbon dioxide emissions are recognized issue for cement and concrete industry. This is estimated that 5% of the world's annual carbon dioxide emissions are attributable to cement production. For a long time, carbonation has been considered a reaction that deteriorates the durability of concrete. Carbonation occurs in the pores near surface of concrete and progresses towards the inside of concrete element. The carbonates and hydrates will undergo reaction during casting which forms a hybrid of hydrates and carbonates. These hybrid forms micro reinforcement in concrete texture.

The carbonation of freshly hydrating cement involves the reaction of CO2 with the main calcium silicate phases to form calcium carbonate and silicate hydrate gel

$$3\ CaO\bullet SiO2 + (3\text{-}x)\ CO2 + y\ H2O \rightarrow x\ CaO\bullet SiO3\bullet y\ H2O + (3\text{-}x)CaCO3$$

$$2\ CaO\bullet SiO2 + (2\text{-}x)\ CO2 + y\ H2O \rightarrow x\ CaO\bullet SiO3\bullet y\ H2O + (2\text{-}x)CaCO3$$

The reaction occurs in the aqueous state when Ca2+ ions from the cementitious phases react with CO32_ ions from the applied gas. The carbonation reaction is exothermic evolving 347 kJ/mol for C_3S and 184 kJ/mol for b-C_2S . When the calcium silicates carbonate, the formed CaCO3 is understood to be co-formed with calcium silicate hydrate (C-S-H) gel which itself can lose CaO and water to convert to silica gel . Gel formation has been observed even in the model cases of reacting b-C_2S and C_3S exposed to a 100% CO_2. It was found that the amount of calcium silicate that reacted exceeded the amount that would be attributable to the formation of the carbonate products alone. [3]

The reaction of carbon dioxide with a mature concrete microstructure is acknowledged as a durability issue given effects such as shrinkage, reduced pore solution pH and carbonation induced corrosion. In contrast, a carbonation reaction integrated into concrete production reacts CO_2 with freshly hydrating cement rather than the hydration phases present in mature concrete, and does not have the same effects. [1]Carbon dioxide reacts with hydrates of concrete $Ca(OH)_2$ will be converted to $CaCO_3$ .As a result the volume of CaCO3 will be more than that of hydrates. Thus total porosity reduces due to the formation of $CaCO_3$ is more than $Ca(OH)_2$. The maximum amount of CO_2 that can be stored in cement-based materials depends on the chemical composition of the cement. The following formula:[5]

$$CO2\%\ max=0.785(CaO-\ 0.7SO_3)\ +1.091MgO+1.420Na_2O + 0.935K_2O$$

here, CaO, SO_3, MgO, Na_2O, and K_2O are the mass percentages of relevant constituent oxides. Several approaches can be followed to store CO_2 in concrete.

2.MATERIALS REQUIREMENT

Concrete mixes with a compressive strength of 35 MPa are used for this study. The concrete mix design was done as per IS 456:2000 and IS 10262:2009. The materials were tested for various properties required for the mix design as shown in TABLE 3.1. The cement used for the entire experiment is ordinary Portland cement of grade 53 cement. The coarse aggregates were of size 20 mm and the fine aggregate used was M-sand. Admixture of type GLENIUM SKY 8433 produced by BASF Incorporation, of specific gravity 1.08, was added to increase the workability of concrete and to minimise the amount of water-to-cement ratio .The carbon dioxide was injected into the concrete mixer. For carbon dioxide source, fire extinguisher was provided.

Table No: 1 Beam preparation between Conventional RC and Carbon cure RC structure

Materials			
Cement	(kg)	5.727	5.727
Fine aggregate	(kg)	9.7635	9.7635
Coarse aggregate	(kg)	17.467	17.467
Water	(l)	2.06	2.06
Admixture	(l)	0.001718	0.001718

Fig -2: Carbon cure RC beam

2. TEST PROCEDURES OF PRELIMINARY EXPERIMENT

The materials were placed into the mixer. The aggregates were placed into the mixer over 30 seconds followed by cement after 60 seconds. The carbon dioxide was injected to mixer from 60s for a duration of 3minutes at 0.55 MPa.The water was added for three sets. First, second and third sets of water were poured around 59,112 and 120 seconds respectively. The mixer is covered with plastic sheet to utilize CO2 completely. After the beams are casted, it is kept for conventional curing for 28 days. Fig 1 shows the mixing procedure for carbon cure RC beam (a,b,c,d,e,f,g,and h).

Non uniform corrosion was conducted for comparative study of carbon cure RC concrete and conventional concrete .In marine structure ingress of chloride ions in one direction which makes the upper region of rebar to corrode more easily. Thus corrosion is not having uniform corrosion expansion of rust products. The specimens were partially immersed in saline solution pond in which one of the face touches the saline solution for corrosion test. In this study 20% NaCl solution in the pond were used for accelerated corrosion. The cathode was connected with stainless steel plate and the two anode probes were connected at end of projected steel of carbon cure RC and conventional concrete beam respectively

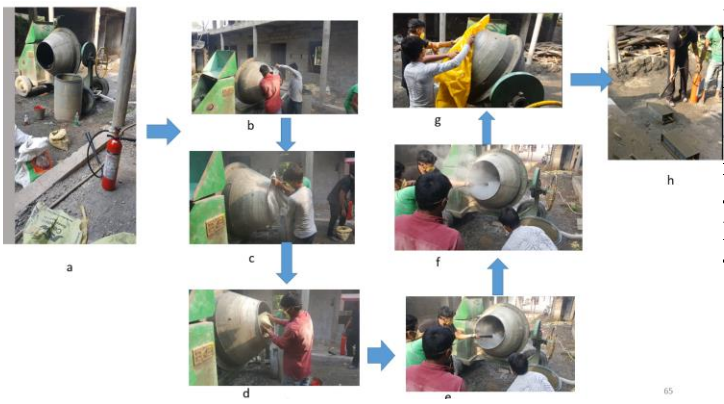

Fig -1: Mixing Scheme

Fig -3: Experimental setup for non-uniform corrosion

3. RESULTS AND OBSERVATION

Carbon cure concrete and conventional concrete were tested non uniform corrosion test. Carbon cure concrete beam showed corrosion spots near the rebar at the second day observation. Conventional concrete showed corrosion spots near the rebar at the first day observation

Corrosion spots were seen on the second day of the corrosion for carbon cure RC beam where corrosion spots were seen after first day for conventional concrete. Corrosion rate was progressive after second day for both conventional concrete and carbon cure concrete.

Fig -4: Carbon cure

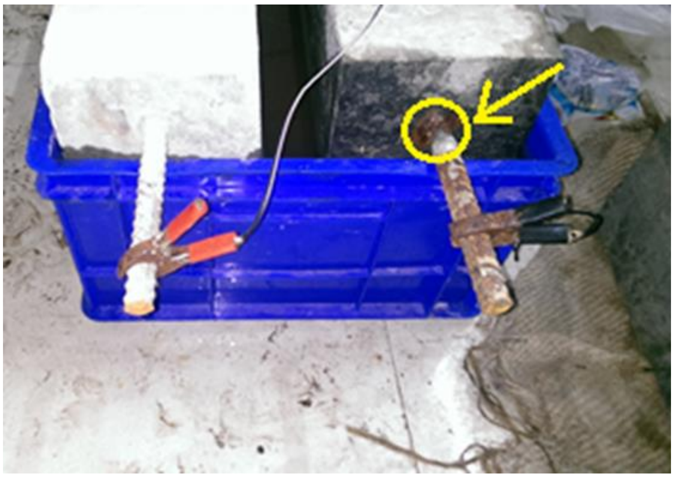

Fig -5 First day observation of corrosion

Fig -6 Second day observation of

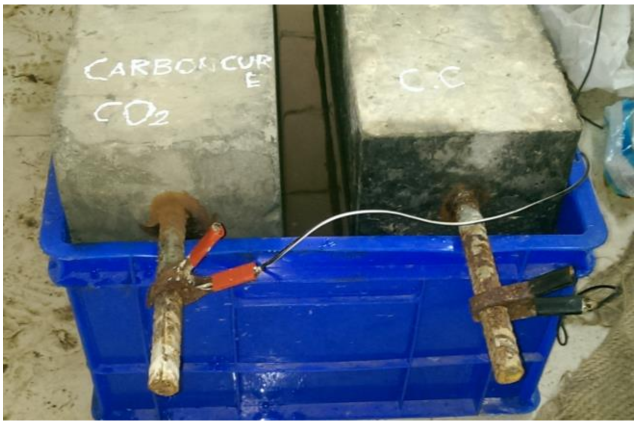

Fig -7 Third day observation of

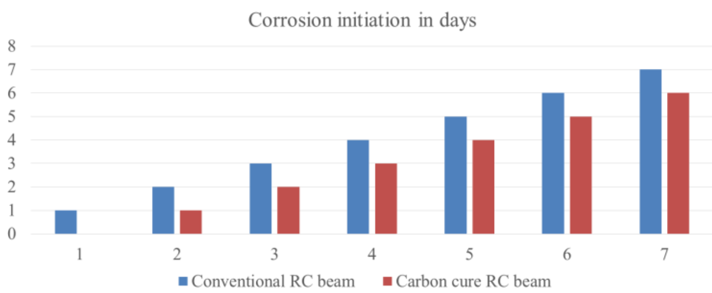

Chart-1: Corrosion initiation rate in days

4. CONCLUSION

It can be concluded that the carbon cure RC beam have finest surface texture. The surface texture becomes hard due reduction in porosity compared with conventional RC beam. The surface texture formed with hybrid of carbonates and hydrates. The hybrid so formed will act as micro reinforcement.

The permeability of chloride ions are slower for carbon cure RC than conventional RC beam. The corrosion spots were seen on second day in carbon cure RC beam compared to conventional RC beam.

Carbon dioxide gas can be reduced from cement factories by using carbon dioxide into concrete blocks and RC beams structures. The main advantage of carbon cure concrete is that it can be used as green concrete. Eco friendly concrete structures for reducing and storing carbon dioxide into blocks and RC structures.

Carbon dioxide can be easily stored and collected from factories and it can be feasibility available for concrete beneficial outcomes. Carbon cure concrete can be used as a retrofit and sustainable element.

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