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Experimental Study of Normal Weight Concrete using Urea as an Additive Material

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***Abstract:*— This work presents an experimental study on influence of urea in concrete through various tests on urea mixed concrete namely, Corrosion Test of steel bar embedded in urea mixed concrete cured in sodium chloride solution using half cell potential, Sorption test and recovery of compressive strength on the long-age were carried out.**

***Index Terms:*— Corrosion test, half cell potential, sorption test,and urea.**

I. INTRODUCTION

This study deals with three major problems in concrete namely heat of hydration, penetrability and corrosion of steel bar embedded in concrete. The reaction of cement with water is exothermic. Reaction liberates a considerable amount of heat known as heat of hydration. Due to the accumulation of hydration heat of cement to the internal temperature of concrete during curing this causes thermal cracks by temperature difference between internal and external part of concrete. The performance of concrete subjected to many aggressive environments depends, to a large extent, on the penetrability of the pores in concrete. Pores in concrete allow contaminants to ingress into concrete which further promotes corrosion of steel bar in concrete.

Corrosion of reinforced steel in concrete represents the major problem worldwide. Reinforced steel corrosion happen mainly due to the penetration of chloride ions to steel surface which destroy the passive film that originally formed on the rebar surface due to the alkalinity of cement paste (pH 12.5–13.5) during concrete casting. Chloride ions act as catalyst to corrosion when present in sufficient amount at rebar surface, they are not consumed in the process and permit the corrosion to proceed quickly in addition they absorb and retain moisture which increase the water content in concrete pores solution and then increase the electrical conductivity of the concrete and accelerate the corrosion.

Use of urea is proved to be helpful in solving all the three problems mentioned above. Urea, also known as carbamide, is an organic compound with the chemical formula Co(NH2)2. It is a colourless, odourless solid, highly soluble in water, and practically non-toxic. Dissolution of urea in water is an endothermic reaction which reduces temperature of mixing water hence it reduces heat of hydration.

Also crystallization of urea in concrete pores reduces penetrability of concrete. Fig 1 shows crystal formation on concrete surface. Also urea fertilizer is organic compound contains two nitrogen atom and one oxygen atom enable it to decrease corrosion rate of metals and alloys.[1-7]

II. EXPERIMENTAL WORK

A. Overview

Sorption test, Corrosion test of steel bar imbedded in urea mixed concrete and Compressive strength test of urea mixed concrete using substitution mixing method were carried out. Table-1 shows materials used in the experiments and The meaning of P and UX are shown in table-2. Urea was mixed with concrete by weight ratio of cement 3%, 5% and 7%. When Urea is mixed into concrete, volume of mixing water gets increased. Therefore volume of mixing water was reduced by the volume of Urea.

Table I. Material Used

MATERIAL NAME	PHOTOS	
Cement	Portland Pozzolana cement	
Urea	Kisan Urea	
Sand	Red Sand	

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MATERIAL	PHOTOS	
Aggregate	20 mm	
	10 mm	
NaCl	NaCl Solution	

Table II. Meaning of specimens

MATERIAL	MEANING
P	0 % Urea mixed with concrete by weight ratio of cement
UX	X % Urea mixed with concrete by weight ratio of cement

B. Experimental Method

B.1. Compressive strength test of urea mixed concrete

Specimens are made and tested according to IS 516 (1959) while IS 10262 is used for concrete mix design. Curing of specimens were done in water maintained at a temperature of 27 □ 20 C. Results shown in table III and graph I corresponds to compressive strength test.

B.2. Sorption test of urea mixed concrete

Sorptivity test was performed in accordance with ASTM 1585 (2004). Purpose of sorptivity test is to determine the rate of absorption of water by concrete. Fig 2 shows sorptivity test. Results shown in table IV to VI and graph II corresponds to sorption test.

B.3. Corrosion test of urea mixed concrete

To show the corrosion inhibition of urea fertilizer, open circuit voltage tests were carried out for reinforced steel embedded in concrete. Fig 3 shows half cell potential measurement. Results shown in table VII and graph III corresponds to corrosion test. The first specimen was a control concrete, the other three specimens consist of the concrete with urea inhibitor at concentrations of 3%, 5% and 7% of cement respectively. All the concrete are of M20 grade.

C. Figures

Fig 1 : Crystallization of urea

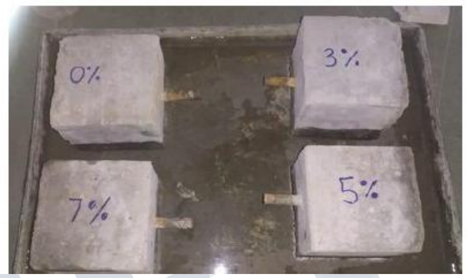

Fig 2 : Sorptivity test

Fig 3 : Half Cell Potential

III. EQUATION

Substitution of urea takes place by using following equation:

$$\frac{Mu}{1320} + \frac{Mw}{1000} = \frac{M}{1000}$$

Where, Mu denotes mass of urea used in concrete taken as a percentage of cement. While Mw denotes required mass of water after adding urea and M denotes design value of water content.

IV. RESULTS

A. Strength of urea mixed concrete

Table III. Result of compressive strength test of concrete of M20 grade in MPa.

Days\U%	P	U3	U5
7	14.2	12.97	10.8
28	25.03	19.125	18.07
91	32.6	34.7	32.1

B. Result of sorptivity test

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Table IV. Weight of specimens at regular interval in grams (g).

Time (min)	P	U3	U5	U7
1	2643	2636	2591	2552
5	2643	2636	2591	2552
10	2643	2636	2591	2552
20	2644.5	2636.5	2591	2552
30	2644.5	2637	2591.5	2552
40	2645	2637.5	2592	2552
50	2645.5	2637.5	2592	2552
60	2645.5	2637.5	2592.5	2552.5
120	2646.5	2638	2592.5	2552.5

Table V. Change in weights of specimens in grams (g). Following table shows change weight (Δm)due to absorption of water.

Time (min.)	Δm P	Δm U3	Δm U5	Δm U7	Area	Density(g/mm3) Of water
5	0	0	0	0	10000	0.001
10	0	0	0	0	10000	0.001
20	1.5	0.5	0	0	10000	0.001
30	0	0.5	0.5	0	10000	0.001
40	0.5	0.5	0.5	0	10000	0.001
50	0.5	0	0	0	10000	0.001
60	0	0	0.5	0.5	10000	0.001
120	1	0.5	0	0	10000	0.001

Table VI. Result of absorption test
Following table shows absorption and Cumulative Absorption of water in mm.

Time (min)	Absorption, mm				Cumulative Absorption, mm			
1	P	U3	U5	U7	U0	U3	U5	U7
5	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
20	0.15	0.05	0	0	0.15	0.05	0	0
30	0	0.05	0.05	0	0.15	0.1	0.05	0
40	0.05	0.05	0.05	0	0.2	0.15	0.1	0
50	0.05	0	0	0	0.25	0.15	0.1	0
60	0	0	0.05	0.05	0.25	0.15	0.15	0.05
120	0.1	0.05	0	0	0.35	0.2	0.15	0.05

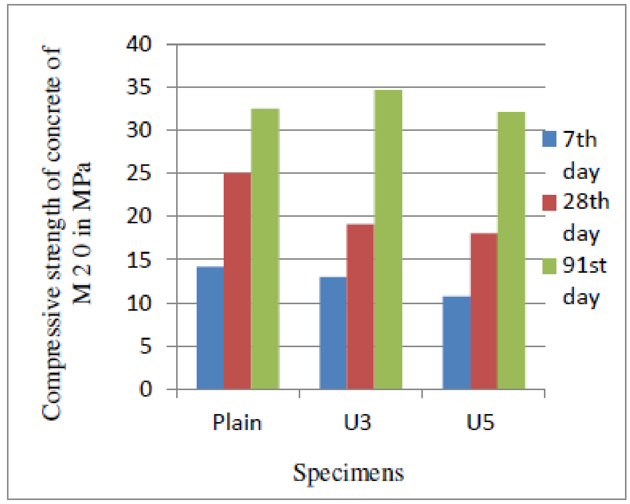
C. Result of corrosion test

Table VII. Result of corrosion test at 28th day.

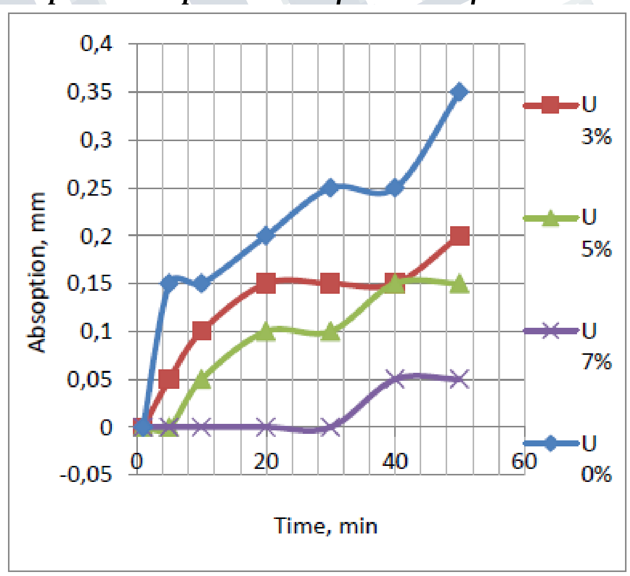
HALF CELL POTENTIAL IN VOLT(V)				
SR.NO.	P	U3	U5	U7
1	-0.468	-0.41	-0.41875	-0.377
2	-0.468	-0.4185	-0.3895	-0.376
3	-0.443	-0.4135	-0.3945	-0.3675
4	-0.371	-0.4195	-0.388	-0.3795
Avg.	-0.4375	-0.4153	-0.3976	-0.375

V. GRAPHS

Graph I. Compressive strength of concrete of M 20 in MPa.



Graph II. Absorption values of Concrete of M20 in mm.



Graph III. Sorptivity Value of Concrete of M20 in mm min^{-1}.

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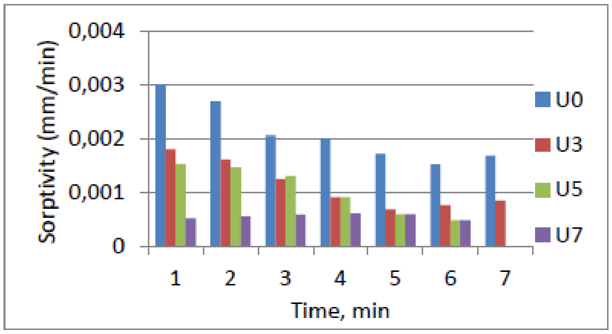

VI. CONCLUSION

[1] Compressive strength test

Experiment shows reduction in strength of concrete cubes in 7 days by 18.66% in U3 and 23.94% in U5 as compared with Plain concrete. After 28 days, reduction in strength is increased to 23.59% in U3 and 27.8% in U5. But after 91 days, experiment showed increase in strength by 6.44% in U3 whereas reduction in strength reduced to 1.534% in U5 compared with Plain concrete. But design strength is satisfied in all levels.

[2] Sorption test

Experiment shows absorption of water by concrete cubes in 120 minutes by 35% in U0, 20% in U3, 15% in U5 and 5% in U7. Experiment shows reduction in sorption i.e. absorption in mm per min of concrete cubes in 30 minutes by 33.28% in U0, 49.72% in U3, 40.78% in U5 whereas increase of 15.5% in U7. After 60 min test shows reduction in absorption in mm per min of concrete cubes by 44% in U0, 53% in U3, 100% in U5 and 100% in U7.

[3] Corrosion test

Experiment shows half cell potential in concrete specimens at 28th day. Half cell values of specimens cured under salt water show severe condition of corrosion in plain and U3 whereas high risk of corrosion in case of U5 and U7.

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