Behavior of Self Healing Concrete Over Plain Cement Concrete

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Abstract*— The experimental research program concerning the development of mechanical properties of a high performance concrete of grade M30 was considered with the following composition. The w/c ratio is chosen as 0.45, Coarse Aggregates were chosen, and having a particle size of 12mm and Fine aggregate were chosen according to a Grade – II. By updating these compositions Mix design for M30 grade is calculated and hence the mix ratio is founded as 1: 2.3: 3.15. The SAP used, is a suspension polymerized, covalently cross linked acryl amide/acrylic acid copolymer. The Super Absorbent polymer was added to the mixture on percentage basis to the weight of the cement. Cubes were casted based on four different categories. Initially, four cubes are casted with the mixture of cement, fine aggregate and coarse aggregate to calculate the compressive strength for 7th, 14th, and 21th days respectively. Extra cubes had been casted in case of any discrepancies. Then with the composition 0.3% of Super Absorbent polymer was added to the weight of cement and cubes were casted. Similarly for 0.6% and 0.9% the same procedure was followed respectively. Compressive strength of the concrete is found on the 7th day for all the four proportions. It had been found that compressive strength decreases when the percentage of SAP increases on comparing with the ordinary mix proportions. Then the same cubes which were tested on the 7th day were once again tested on the 14th day the result came out as there is an increase in compressive strength of the concrete. Here the addition polymer helps in increase of the compressive strength of the concrete. Similarly the same procedure had been followed for 14th day and 21th day respectively. The quality of the concrete and depth of crack on the concrete were found using Ultrasonic pulse velocity test. It gives clear picture over depth of cracks before testing and after testing the cubes for compression test. Conclusions were made based on the tested results and finally crack self - healing behaviour of concrete were found over plain cement concrete.

Keywords: Compressive Strength; Super Absorbent Polymer; Self Healing.

I. INTRODUCTION

Concrete cracks due to its low tensile strength. The presence of cracks endangers the durability as they generate a pathway for harmful particles dissolved in fluids and gases. Without a proper treatment, maintenance costs will increase. Self-healing can prevail in small cracks due to precipitation of calcium carbonate and further hydration. In the current research, crack sealing is also enhanced by the application of superabsorbent polymers. When cracking occurs, superabsorbent polymers are exposed to the humid environment and swell. This swelling reaction seals the crack from intruding potentially harmful substances. Regain in mechanical properties upon crack healing was investigated by the performance of four-point-bending tests, and the sealing capacity of the superabsorbent polymer particles was measured through a decrease in water permeability. In an environment with a relative humidity of more than 60%, only samples with superabsorbent polymers showed healing. Introducing some % of superabsorbent polymer gives the best results, considering no reduction of the mechanical properties in comparison to the reference, and the superior self-sealing capacity. A longer service life will reduce the demand for both new structures and repair costs. Furthermore, the usage of raw materials,environmental pollution, energy consumption and CO_2 production will decrease, deviously. Therefore, self-healing of concrete seems to be a promising approach economically and ecologically. Self-healing is generally defined as the ability to recover or heal the damage of materials. For concrete structures, the need in self-healing is mostly in closing cracks. The mechanisms of self-healing in concrete are usually related to further hydration of unreacted cement, swelling of concrete, formation of calcium carbonate crystals and closing of cracks by solid matter in the water. The main objective of this research is to investigate the self-healing behaviour of concrete over plain cement concrete.

EXPERIMENTAL PROGRAM:

Materials Used:

Cement:

The Portland Pozzolana Cement conforming was used for the preparation of test specimens.

A. Fine Aggregate:

The fine aggregate used in this experimental investigation was natural river sand confirming to zone II

B. Natural Coarse Aggregate:

Crushed granite aggregates particles passing through 20mm and retained on 4.75mm I.S sieve was used as natural aggregates which met the grading requirement.

C. Water:

Portable water available in laboratory was used for mixing and curing the concrete specimens.

D. Super Absorbent Polymer:

The water absorbent capacity of these types of materials is only up to 11 times their weight, but most of it is lost under moderate pressure.

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Table 1. MATERIAL TEST

CEMENT(53 GRADE OPC)	
SPECIFIC GRAVITY	3.33
STANDARD CONSISTENCY	33 mm for 27%
FINE AGGREGATE	
SPECIFIC GRAVITY	2.56
FINENESS MODULUS	3.09
COARSE AGGREGATE	
SPECIFIC GRAVITY	2.69
WATER ABSORPTION	0.2%

Table 2. MATERIAL MIX

M30 GRADE CONCRETE	
CEMENT	450 kg/m^3
FINE AGGREGATE (SAND)	502 kg/m^3
COARSE AGGREGATE	1230 kg/m^3
WATER	192 kg/m^3
RATIO 1 : 2.3 : 3.15	

Table 3. COMPRESSIVE STRENGTH BEFORE HEALING PERIOD

S. NO	% SAP	COMPRESSIVE STRENGTH (Before Healing Period) (N/mm^2)			
		7D D	7D W	14D W	21D W
1	-	30.22	33.24	34.44	40.09
2	0.3	29.73	29.47	37.51	36.13
3	0.6	23.56	22.93	30.49	38.44
4	0.9	30.22	30.40	33.38	37.20

Table 4. COMPRESSIVE STRENGTH AFTER HEALING PERIOD

S. NO	% SAP	COMPRESSIVE STRENGTH (After Healing Period) (N/mm^2)			
		7D D	7D W	14D W	21D W
1	-	33.02	42.84	42.09	45.20
2	0.3	33.78	35.02	38.18	42.09
3	0.6	24.80	29.96	33.96	41.02
4	0.9	36.80	34.40	36.31	42.40

Fig 1. 0% Super Absorbent Polymer

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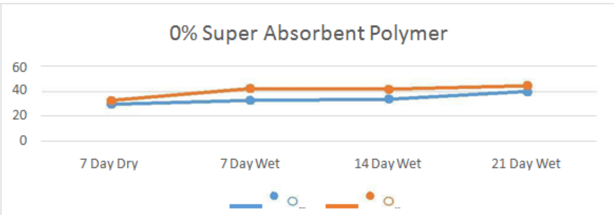


Fig 2. 0.3% Super Absorbent Polymer

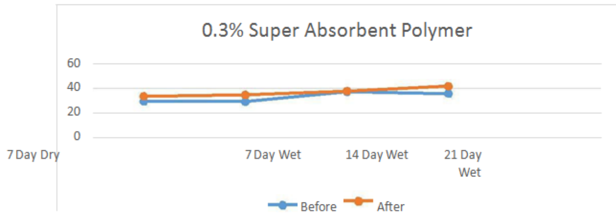


Fig 3. 0.6% Super Absorbent Polymer

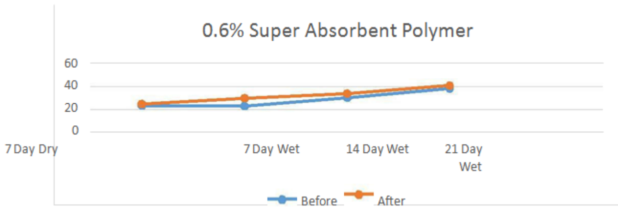
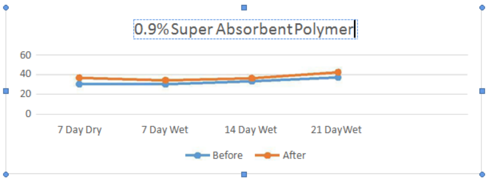


Fig 4. 0.9% Super Absorbent Polymer



UPV TEST

Table 5. CRACK DEPTH

S.NO	% SAP	DEPTH (cm)							
		CYCLE 01				CYCLE 02			
		7D D	7D W	14D W	21D W	7D D	7D W	14D W	21D W
1	-	34	33	39	902	55	89	105	1017
2	0.3	37	34	36	813	91	193	123	947
3	0.6	32	32	36	865	171	149	102	923
4	0.9	35	31	35	837	89	131	142	954

Table 6. BRINELL'S MICROSCOPE

S.NO	CRACK WIDTH [CYCLE 1]								CRACK WIDTH [CYCLE 2]							
	A (mm)				B (mm)				A (mm)				B (mm)			
	7D D	7D W	14D W	21D W	7D D	7D W	14D W	21D W	7D D	7D W	14D W	21D W	7D D	7D W	14D W	21D W
0.3 % of SAP																
1	1	0.9	0.8	0.8	0.7	0.6	0.5	0.4	0.8	0.7	0.6	0.5	0.7	0.6	0.5	0.4
2	0.5	0.4	0.3	0.2	0.4	0.3	0.2	0.2	0.4	0.3	0.3	0.2	0.4	0.3	0.3	0.2
3	0.4	0.3	0.2	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1
0.6 % of SAP																
1	0.4	0.3	0.2	0.2	0.4	0.3	0.2	0.2	0.3	0.2	0.1	0.1	0.2	0.2	0.2	0.1
2	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.1
3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
0.9 % of SAP																
1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2	0.1	0.1	0.1	0.1	0.3	0.3	0.2	0.1	0.3	0.2	0.2	0.1	0.4	0.3	0.2	0.1
3	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.1

TYPICAL FAILURE PATTERN CONCLUSION:

The use of sodium polyacrylate as super absorbent polymer in concrete has promising potential to improve several properties of concrete including the concrete strength. This can be explained by providing internal curing source that releases moisture slowly over days and may be weeks. This increase in strength is relatively small even at the optimum amount of sodium polyacrylate used in the concrete. This may become advantageous in the absence of concrete curing. Excessive amount of sodium polyacrylate used in concrete has a substantial negative effect on the concrete strength. Other important properties can be improved using this type of admixture especially concrete stability, where the gel provides cushioning to the large aggregates which is in turn reduces the possibilities of concrete segregation. Frost resistance is the other important property that can be improved by using this admixture, by absorbing the hydraulic pressure generated by water expansion. Adding SAP to the concrete mix makes the fresh concrete more plastic and uniform. This helps in placing and finishing the concrete.

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