SELF HEALING CONCRETE USING SUPER ABSORBENT POLYMER

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Abstract

Study about Self-healing concrete and its strength parameters is very important criteria in recent concrete industry. The major problem in the application of concrete is crack formation which may be structural or non-structural. These cracks reduce the durability of the concrete. This is because concrete provides a convenient way to transport liquids and gases. Therefore, maintenance and repairs are inevitable. A variety of external methods can be used to repair the crack, but the solution is expensive, time consuming, and in some cases unattractive. If cracks occur in hard-to-reach places, they must be sealed without damaging the structure. Therefore, there is a need to develop concrete that can repair cracks without external maintenance. This self-healing property can be achieved in physical, chemical, or biological ways. This paper studies the strength parameters of self-healing concrete by combining with superabsorbent polymer (SAP). Because SAP (sodium polyacrylate) is a chemical polymer that can be used as a self-healing agent, concrete can repair cracks without manual maintenance. Samples are cast with an additional 0%, 0.25%, and 0.50%, and tested at the 7th and 28th cures to determine the compressive, flexural, and impact strength of concrete using SAP Was. The results show that the strength of the concrete increases only with increasing curing period.

Keywords: *SAP- Super Absorbent Polymer, sodium polyacrylate.*

I Introduction

Concrete is the mixture of Cement, Coarse aggregate, Fine aggregate and Water. All the structural components area commonly made with concrete due to more amount compressive strength and durable. At the same time concrete weak in tensile strength.

In that case all the structural members in tension members like beams, slabs are made compositely with Reinforced Steel Bars for the bearing of tension loads. In general, non-structural factors, such as structural loads or shrinkage, thermal effects, and physicochemical reactions, add to the cracks in concrete. [1] Cracks may occur on the concrete surface and reach the rebar. This exacerbates the deterioration of the embedded rebar. This crack can cause leakage and affect water tightness. This is an important service life requirement for many structures, such as basements, retaining walls, reservoirs, dams, tunnels, pipes, and waste storage. [2] A variety of external methods can be used to repair the crack, including manual repair with epoxy resin or polyurethane, and coating of the concrete surface by electrodeposition of the compound. These solutions are expensive, time-consuming, and in some cases

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unattractive. If a crack is found in hard-to-reach places, it cannot be repaired manually. Therefore, it is important to develop concrete that can heal and contain its own cracks.

Self-Healing Concrete

This is possible with the techniques developed in the recent advancements of internal active treatment of cracks in concrete. The self-healing property can be achieved by any of the following methods.

- Self-healing by physical action
- Self-healing by biological action
- Self-healing by Chemical action

Self-healing by biological action refers to the technique of adding various bacteria like Bacillus subtilis which could acted as long term crack sealing in effectively, this action works at the life time of concrete.

These bacteria act as catalysts, converting precursor compounds into appropriate filler materials. Newly generated compounds, such as calcium carbonate-based materials, act as bio adhesives and seal newly formed cracks.

Chemical self-healing refers to the technology of adding different chemical polymers and chemically reacting with concrete cement to create a calcium carbonate-based material to repair the cracks that have formed. These polymers can be encapsulated in capsules or mixed with cement before pouring concrete. These capsules are embedded in a concrete matrix. When concrete cracks or capsules are exposed, the capsules burst and the polymer reacts with the cement to produce a product that can repair the crack.

Super Absorbent Polymer (SAP)

Of the sodium polyacrylates, it is used as a self-curing agent of sodium polyacrylate having the formula [-CH2-CH (COONa) -]. [4] Sodium polyacrylate consists of multiple pairs of acrylic compounds with positive and anionic charges that attract and bind water molecules, making sodium polyacrylate highly absorbent. The superabsorbent polymer shown in Figure 1 is a chemical agent that inappropriately absorbs large amounts of water when added to conventional concrete. [5] SAP after water absorption becomes an insoluble soft gel as shown in Figure 2 and its volume increases.

[6] When concrete is formed due to shrinkage or other reasons, SAP is exposed to the atmosphere. The exposed SAP absorbs moisture from the atmosphere and seals the cracks created by the swelling. The water absorbed by SAP is released after a period of time and is used to hydrate the cement [3]. It is also widely used in agriculture.

Fig. 1 Super Absorbent Polymer (SAP)

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Fig. 2 SAP after addition of water

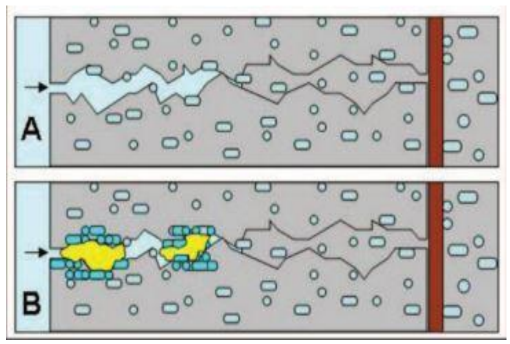

Fig. 3 Schematic representation of effect of SAP

In Fig. 3 A shows, the formation of crack and the entry of moisture into concrete, B shows, the swelling of SAP after entry of moisture thus filling the crack and preventing the reinforcement from corrosion.

II Materials Used

The raw materials used in this study were locally available, including ordinary Portland cement (O.P.C) as binder and M sand as thin and coarse aggregate. Portable tap water was used for mixing throughout the study. Confirmed limits and limits for drinking water according to I.S 456-2000.

Cement: Ordinary Portland cement grade 53, conforming in order to I.S 12269-1987 has been used. Ordinary Portland Cement (OPC) initial setting time is very low. OPC costly compared with PPC. Because of purest form cement content in Test purposes, OPC used.

Fine Aggregates: Fine aggregate used for this experimental study for concrete is M-sand which are laying under Zone-II as per I.S 383-1970. Fine aggregate is one of the filling material in combination with cement named as mortar.

Coarse aggregate: Coarse aggregate is used like inert and main core of concrete. Coarse aggregate with IS: 383-1970 was used. The maximum size of coarse aggregate used was 20 mm. Coarse aggregate carried impact from the loading.

Water: The water should be fresh, colorless, tasteless and tasteless. Portable water available at home is used for mixing and treating concrete samples [2].

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III Mix Proportion

The Quantity of materials per cubic meter is arrived [1] and mix ratio are described in Table. 1

Table.1 MIX RATIO

Cement in (kg/m^3)	**Fine Aggregate in (kg/m^3)**	**Coarse Aggregate in (kg/m^3)**	**Water in (l/m^3)**
438	709	1103	197
1	1.52	2.52	-

IV Results and Discussions

Compressive Strength

Compressive strength of concrete can find using concrete cubes (150 mm X 150 mm X 150 mm) in Compression testing machine. This research compressive strength calculated using conventional concrete ratio and SAP concrete mix ratio. Test results are tabulated as below no.2. Concrete cubes casting in two types curing 7 days and 28 days. 7 Days curing concrete cube specimen get 67.5% of compressive strength of at the same time 28 days curing concrete cube specimen get 99% of compressive strength.

Table. 2 – Compression Test results on cubes

Days of curing	Conventional concrete (0%) **(N/mm^2)**	SAP concrete (0.25%) **(N/mm^2)**	SAP concrete (0.5%) **(N/mm^2)**
7	21.1	21.5	33.5
	21.3	21.7	27.7
	25.3	28	28.6
28	36.6	26.4	36.9
	30.2	30.8	36.2
	38.4	31.7	32

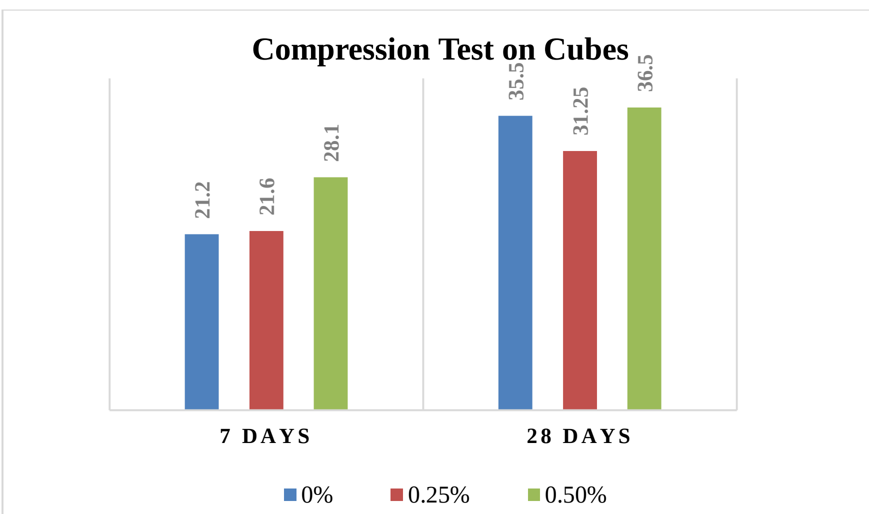

Fig. 4 compressive strength results

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Tensile or Flexural Strength Test

Flexural Strength test carried on prism specimen. Flexural strength test can identify the tensile strength of concrete because of concrete weak in tension. The flexural strength test done both conventional concrete ratio and SAP concrete mix ratio. Test results are tabulated as below no.3

Table. 3 - Flexural strength of conventional and SAP concrete

Days of curing	Conventional concrete **(N/mm²)**	SAP concrete (0.25%) **(N/mm²)**	SAP concrete (0.5%) **(N/mm²)**
7	4.5	0.75	2.2
	7.5	0.75	1.8
	6	1.8	1.3
28	6.8	6.4	7.8
	7.8	4.9	7.1
	8.3	6.8	6

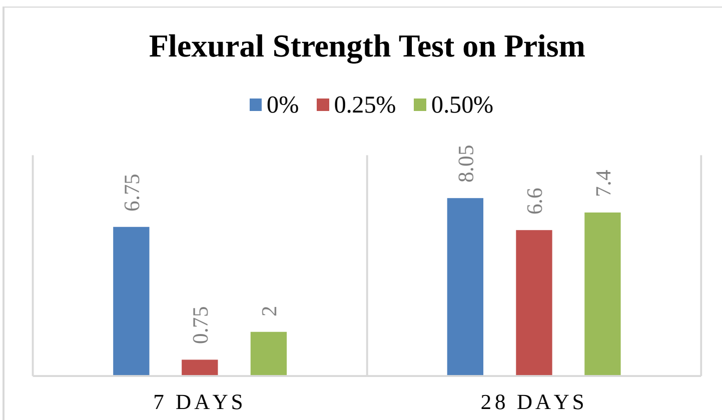

Fig.5 Flexural strength test results

Impact strength

Impact Strength test on concrete slabs performed for impact strength analysis of concrete slab due to sudden loading. The flexural strength test done both conventional concrete ratio and SAP concrete mix ratio. Test results are tabulated as below no.4

Table 4 - Impact strength of conventional and SAP concrete

Days of curing	Conventional concrete **(N/mm²)**	SAP concrete (0.25%) **(N/mm²)**	SAP concrete (0.5%) **(N/mm²)**
7	7.5	7.5	7.5
	7.5	7.5	7.5
28	7.5	7.5	7.5
	7.5	7.5	7.5

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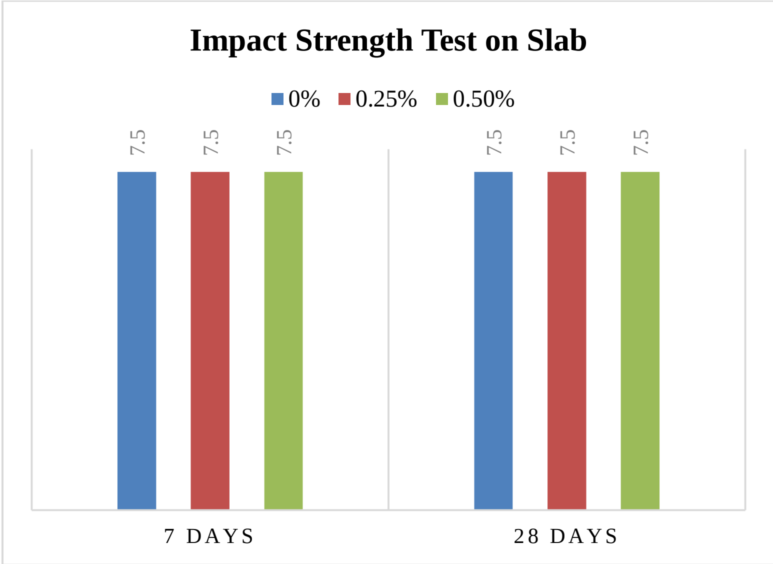

Fig. 6 Impact strength test results

V Conclusions

- The strength parameters of conventional concrete and SAP concrete were compared.
- It was found that SAP added concrete results increased at age of curing increased compression tests results and it was also found that adding SAP more than 1% had opposite reaction in result.
- Added with SAP do not impact in flexural or tensile strength of concrete when curing is done for long duration.
- Scalactics were formed on the surface of concrete as shown in Fig. 7.
- It was also found that addition of SAP do not have any effects on the impact strength of concrete.

Fig. 7. Formation of Scalactics

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References

[1] Arn Mignona.B, Didier Snoecka, "David Schaubroeckc, Nathalie Luickxd, Peter Dubruelb, Sandra Van Vlierbergheb, Nele De Beliee" (2015) pH-responsive superbsorbent polymers: a pathway to self healing of mortar, Vol.3, pp. 1381-5148.

[2] Asad shaikh et al., "self-healing concrete by bacterial and Chemical admixtures", Vol. 8, 2017, pp.145-152.

[3] Danieal Cussion et al., "Practical applications of superabsorbent Polymers in concrete and Other Building Materials", Vol. 10, 2012, pp.137-148.

[4] Didier snoeck et al., "How to seal and heal cracks in cementitious materials by using superabsorbent polymers", 2014, pp. 375-384.

[5] Hai Xing Dennis et al., "Selsealing cement based materials using superabsorbent polymers", International RILEM conference, Denmark, 2010.

[6] H.X.D. Lee et al., "The potential of superabsorbent polymer for self-sealing cracks in concrete", 2010, Vol.109, pp.296-30.

[7] M.Sivaranjani et al., "Study on the properties of concrete by using super Absorbent Polymer", Vol.5, pp.2321-9653.

[8] IS 10262-1982, " Indian Standard recommended methods of concrete mix Design", Bureau of Indian standard, 1982.

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