Experimental Studies on Slump and Strength Properties of Concrete with Natural Admixture

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Abstract

Admixtures are frequently employed in the construction sector to enhance the various properties of concrete. Plasticizers are water reducers which are extensively used in the construction industry. However, use of chemical admixtures in concrete is proven to have undesirable effects on the environment due to the presence of formaldehyde, which is hazardous when released into the environment. Hence, there is a need to develop an alternative derived from natural materials which is low-cost, eco-friendly and equally efficient as chemical admixtures. In this study, a natural admixture prepared from the extract of a locally available tree pod is used to investigate the effect its addition on properties of concrete. Tests on workability, compressive strength, splitting tensile strength and flexural strength were carried out on concrete specimens and the results of different mixes compared. The results obtained by the addition of natural admixture are compared with that of the control mix having no admixture and mix containing chemical admixture for better understanding of its behaviour. There was an enhancement in the concrete's workability with the addition of natural admixture when compared to the control mix. An increase in the strength of concrete in compression, tension and flexure was also observed. Hence, use of natural admixture can prove beneficial in improving the fresh and hardened properties of concrete. Therefore, NP prepared from the tree pod extract can be considered to have the potential to be utilized as an efficient, low-cost and eco-friendly alternative to chemical admixtures.

Keywords: *Natural admixture, Plasticizer, Strength, Tree pod, Workability*

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1. Introduction

Many chemical admixtures are in use in the construction sector to improve various properties related to concrete. Plasticizers are admixtures which are used for reduction of water, enhancement of concrete's workability and compressive strength in its fresh and hardened states (Mailavaganam, 1999). Chemical admixtures improve the characteristics of concrete while also contributing to environmental degradation (Patel & Deo, 2016; Plank, 2004). Now-a-days many admixtures prepared from natural organic materials are being researched upon in order to find a way of reducing the use of chemical based admixtures as they are known to be harmful to the environment. Natural admixtures can prove beneficial and may have the potential to replace chemical admixtures (Arum & Olotuah, 2006; Dwivedi et al., 2008; Hazarika et al., 2018; Lee et al., 2018; Mahmood et al., 2021; Otoko & Ephraim, 2014; Ravi & Thirumalini, 2019) Utilization of natural admixtures in place of chemical admixtures may lead towards sustainable construction practices. The additional advantage of using natural admixtures is their low-cost and environmentally friendly nature, apart from working efficiently and similar to the chemical admixtures. In this study, the natural admixture used was an aqueous solution prepared from the extract of the rain tree pod. The Rain tree (Albizia saman/Samanea saman) shown in Figure 1(a) is a widely distributed tree in tropical regions. The

pods of the tree shown in Figure 1(b) ripen & fall in enormous quantities which are left unused and go to waste. The pods are sticky in nature (Staples & Elevitch, 2006) and may help in lubrication purpose. Therefore, the feasibility of using the prepared natural admixture in concrete to enhance its properties is investigated in this study.

(a) (b)

Figure 1. (a) Rain tree (b) Rain tree Pod

2. Materials &Methodology

2.1Materials

In this investigation, OPC (Ordinary Portland Cement) of grade 53 complying with IS 12269:2013 and potable water was employed for all experiments. Table 1 lists the ingredients of cement. Table 2 displays the cement's physical properties. The fine aggregate used was crushed aggregate (manufactured sand or m-sand); and coarse aggregate used was 20mm and downsize, both aggregates conforming to IS 2386-2002 and IS 383-2016 respectively. The properties of fine aggregates and coarse aggregates are shown in Table 3. An aqueous solution made from rain tree pod extract served as the natural admixture in this study. Chemical admixture (CA) used was Sulfonated Naphthalene Formaldehyde (SNF) based plasticizer manufactured by Fosroc. Natural admixture (NA) was prepared from the pods of the rain tree. The tree pods were collected and deseeded in required quantity. The deseeded pods were crushed and soaked in water and subjected to subsequent fermentation to obtain the natural admixture. Table 4 lists the characteristics of the admixtures. The solid contents in the admixtures were determined as per Annex E of IS 9103:1999. Admixtures for addition in concrete are calculated as percentage by weight of cement.

Table 1. Constituents of cement

Constituents	Quantity (% by mass)
Calcium oxide (CaO)	62.15
Silica (SiO_2)	19.4
Alumina (Al_2O_3)	5.01
Iron oxide (Fe_2O_3)	4.06
Magnesium oxide (MgO)	1.58
Sulphur anhydrite (SO_3^{2-})	2.83
Insoluble residue	2.38
Loss on ignition	3.51
Chloride content (Cl^-)	0.022
Alkali content: Sodium oxide	0.44
Potassium oxide	0.47

Table 2. Physical properties of cement

Properties	Results
Normal Consistency (%)	29.5
Specific Gravity	2.97
Initial Setting Time (min)	270
Setting Time, Final (min)	415
Fineness (%)	3

Table 3. Properties of aggregates

Property	Fine Ag.	Coarse Ag.
Specific gravity	2.57	2.73
Water absorption	2.00	0.625
Fineness modulus	3.5	8
Bulk density, kg/m^3	1649	1513

Table 4. Properties of admixtures

Admixture type	Appearance	Density kg/L	pH	Solid Content
Chemical	Dark brown	1.20	>6	42%
Natural	Brown	1.06	7.5-8.5	8%

2.2 Methods

M25 grade concrete was used for all experiments and the mix proportions were calculated based on IS 10262:2019. Table 5 shows the proportions of mix designed for medium workability. The dosages of admixtures used for casting specimens were based on workability requirements. The workability of fresh concrete was studied by performing the slump cone test in accordance with IS 1199-1959. Slump test was performed on fresh concrete mixes with and without the addition of admixtures in addition to the control mix. For mixes with admixtures, the slump values were determined by varying the dosages of admixtures until the desired slump of 90mm for medium workability condition was achieved. The slump of concrete is determined by measuring the height of subsidence of concrete before and after removing the concrete slump cone in mm. The optimum dosage required for the desired slump was noted. The hardened properties of concrete were studied due to the addition of natural admixture and the results compared with the control mix (without any admixture) and mix with chemical admixture. Tests on compressive strength and flexural strength were carried out on hardened concrete as per IS 516-1959 and splitting tensile strength test on hardened concrete was carried out as per IS 5816-1999. Test specimens for compressive strength were cubes with dimensions 150mmx150mmx150mm. For split-tensile test, cylindrical specimens having a diameter of 150mm and length of 300mm were cast. Flexural strength specimens were beams of 150mmx150mm cross-section and 700mm length. All the tests were carried out on three specimens under laboratory conditions and the average result reported in the study. The strengths of concrete were determined at the ages of 7th day, 14th day and 28th day after the curing.

Table 5. Design mix of M25 grade concrete

Materials	Qty./m³
Cement, kg	375
Fine- Aggregate, kg	659
Coarse- Aggregate, kg	1190
Water, kg	169

3. Results and Discussion

Slump test was performed on concrete mixes with and without admixtures (chemical and natural) with varying dosages. It was observed that the slump increased with an increase in admixture dosage (Jayasree & Gettu, 2010). However, to achieve the dosage of natural admixture required was higher than that of the chemical admixture. A dosage of 0.5% of chemical admixture and 1.25% of natural admixture was required to achieve a slump of 90mm for water cement ratio of 0.45. For a dosage of 1.0%, collapse slump was observed for mix with chemical admixture. The slump obtained for the control mix was 15 mm for a w/c of 0.45. Figure 2 shows the variation of slump with different admixture dosages. The water cement ratio required for the control mix to achieve a slump of 90mm was determined to be 0.49. Therefore, the addition of NA proved beneficial in achieving better slump compared to the control.

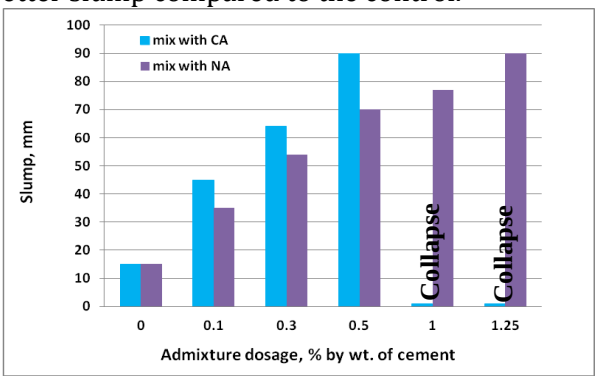

Figure 2. Slump of concrete

The strengths of concrete in compression, tension and flexure for different mixes were determined after curing at ages of 7th day, 14th day and 28th day. The obtained results for compressive, splitting-tensile and flexural strengths of concrete are as shown in Table 7, Table 8 and Table 9 and the corresponding graphs are plotted in Figures 2, 3 and 4. It can be clearly seen that the in the 28-days strength of concrete in compression due to the addition of NA is slightly higher when compared to that of the control mix and mix with CA. The values of strengths of concrete in tension and flexures are the highest for concrete in the presence of natural admixture.

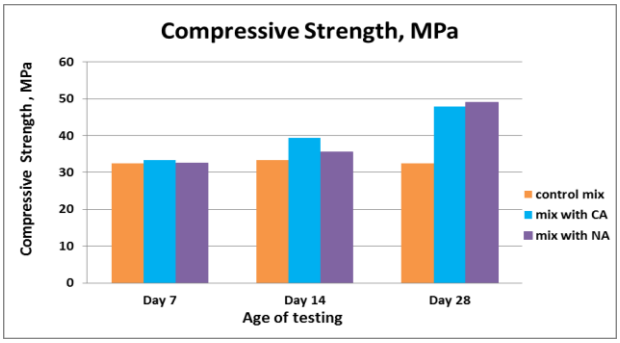

Figure 3. Compressive strength of concrete

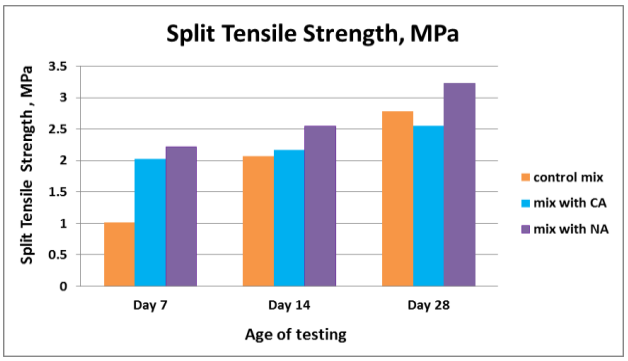

Figure 4. Split-tensile strength of concrete

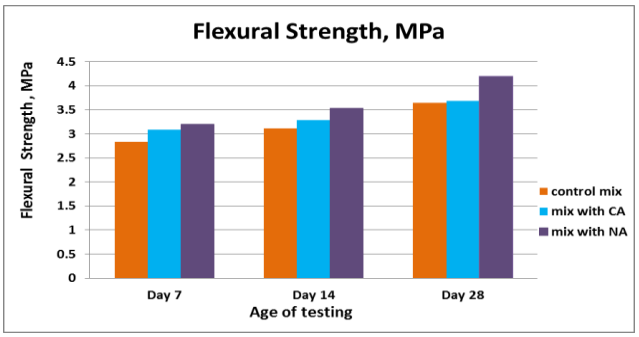

Figure 5. Flexural strength of concrete

4. Conclusions

The present study focused on utilization of natural admixture prepared from tree pod in concrete to investigate its effect on properties of concrete. The work also determines the feasibility of using the developed admixture as replacement for chemical admixtures in concrete. The following are the conclusions drawn from the study.

I. The optimum dosage of natural admixture for achieving medium workability of concrete was found to be 1.25%. A dosage of 0.5% of chemical admixture was required to produce the same workability. Therefore, a slightly higher dosage of natural admixture compared to chemical admixture was required to achieve the same workability. The addition of natural admixture in concrete proves beneficial in enhancing the workability of concrete.

II. The 28-day strength of concrete in compression in the presence of natural admixture was found to be 8% greater than that of the control mix and 2.5% more than the chemical admixture. No strength reduction was observed in the 7th day and 14th day compressive strengths of concrete with natural admixture when compared to the control.

III. The strengths of concrete in tension and flexure were found to be the greatest for the mix with natural admixture for all ages of testing.

IV. Therefore, the developed natural admixture can be recommended for use as an efficient, low-cost and eco-friendly plasticizer in concrete.

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Disclosure Statement

All authors declare that they have no conflicts of interest.

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