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Research paper

Effect of Utilizing Prosopis Juliflora Ash as Cementitious Material

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Abstract

Since the building made of cement concrete consumes almost half of the total energy generated and accordingly accountable for huge amount of CO_2 emission, it is necessary to replace the Portland cement (PC) with sustainable construction material. Similarly, Prosopis juliflora is a shrub or small tree in the family Fabaceae, a kind of mesquite which is considered to be a potential threat for ground water in South India. Hence, this has to eradicate so as to maintain the groundwater and also to effectively utilize its ash thereby reducing environmental pollution, this can be used as a partial replacement for cement. In this regard, this paper investigates the technical feasibility of using prosopis juliflora ash (PJA) as cementitious material by partially (10, 20, 30 and 40 %) replacing cement by prosopis juliflora ash. The mixes were evaluated for their fresh, physical and strength properties such as workability, density and compressive strength and the results were compared with the conventional mix

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1. Introduction

Concrete is the most widely recognized material utilized as a part of construction industry. Cement is the major component of concrete used for building and civil engineering construction [1]. For each human being approximately 1 ton of concrete is produced each year in the world [2]. Therefore cement is one of the World's most significant manufactured materials. 5% of the total release of CO_2 to the atmosphere is caused during the manufacturing for cement in cement industries [3]. In an effort to reduce anthropogenic CO_2 emission and for the economic reasons by-products are used as cementitious materials [4]. Utilization of non-regular and creative materials, and reusing of waste materials to repay the absence of common assets and to discover elective routes for moderating the earth [5]. Many industrial by-products and waste materials such as copper slag [6], fly ash [7], waste brick, bottom ash [8], timber waste [9], ground granulated blast slag [10] were used as replacement of cement. Prosopis juliflora is a bush or little tree in the family Fabaceae, a sort of mesquite. Prosopis juliflora, once touted as a saviour of the dry spell inclined. Prosopis was presented in India amid the 1870s to take care of the fuel wood demand. Prosopis juliflora is a invasive plants, which is the reason for negative biodiversity in many partsof the world. With intense infiltrating roots, it can draw water from very great layers. Its underlying foundations can develop to an incredible profundity looking for water. It sucks excessively of groundwater by profound entrance of their underlying foundations and furthermore makes the water toxic. No other plant or bush could become alongside it. Fresh properties of cement such as consistency and setting time, density, soundness were evaluated.
Five different proportions for cement paste and mortar were prepared. Compressive strength on 3, 7 and 28 days were evaluated.

2. Materials and Methods

2.1 Materials

Cement
OPC 43 grade cement with minimum compressive strength of 45 MPa and initial setting time of 32 minutes and specific gravity of 3.15 obtained from the local supplier was used in this investigation with the chemical composition detailed in Table 1.

Prosopis Juliflora
Prosopis Juliflora Ash (PJA) obtained from the nearest field with a specific gravity 3.00, mean particle size 35 µm was used as a partial replacement of cement in this investigation. The chemical composition of the ash is given in Table 1.

Table 1: Chemical composition of the source materials used

Oxide (%)	CaO	K_2O	SO_3	MgO	SiO_2	Na_2O	Fe_2O_3
OPC	63.12	0.63	1.43	2.16	24.52	0.44	3.51
PJA	59.45	23.85	4.44	1.70	1.19	0.84	0.57

Table 2: Mix Proportion Table for Cement Paste

Replacement of cement with prosopis juliflora ash (%)	Cement (g)	PJA (g)	Water (ml)
M1	600	0	210
M2	540	60	210
M3	480	120	210
M4	420	180	215
M5	360	240	215

Compressive strength of cement paste when cement replaced with various percentage of prosopis juliflora ash for 3, 7 and 28 days were tested. The results are summarized and shown in table 3.

Table 3: Compressive Strength of Cement Paste

Replacement of cement with	3 days	7days	28days

prosopis juliflora ash (%)			
M1	28.18	35.25	51.25
M2	21.18	31.56	44.53
M3	19.51	22.34	35.81
M4	16.62	17.62	34.43
M5	15.12	16.51	27.25

Aggregates

Locally available graded river sand was taken as fine aggregates with a nominal maximum size of 4.75 mm with a specific gravity of 2.6 and crushed granite as coarse aggregate with a maximum size of 16 mm with a specific gravity of 2.64.

2.2 Mix Design

The mortar samples were prepared in the proportion of 1:3.The mixes were prepared confirming to Indian standards, IS 10262:2009. Five different mixes of cement paste and mortar with cement replacement of 0%, 10%, 20%, 30%, and 40 % were prepared. The mixes were placed in the cube moulds with a three layer compaction. The moulds were cured in water bath under room temperature condition for the designated testing period.

Table 4: Mix Proportion of Cement Mortar

Replacement of OPC with PJA (%)	Cement (g)	PJA (g)	Sand (g)	Water (ml)
0	925	0	2775	453
10	832.5	92.5	2775	453
20	740	185	2775	453
30	647.5	277.5	2775	485
40	555	370	2775	485

2.3 Testing Methods

Consistency and setting time of different mixes with 0% to 40% replacement of cement were carried out based on Indian standards IS:4031:Part 4 and soundness test based on IS:4031:Part 3 were carried out. Based on IS: 4031: Part 10 shrinkage test were done on mould size of 76 x 10 x 10mm size. Cube specimens of 40 x 40 x 40 mm size were used for compressive strength of cement paste. Specimens for mortar were placed in a cube of 70 x 70 x 70mm. The compressive strength test for both cement paste and mortar for 3, 7 and 28 days were carried out.

3. Results and Discussion

Consistency and initial setting time

The fresh properties such as consistency and setting time were analyzed and their results are detailed in figure 1.the results of consistency test shows that the optimum water content required for cement paste is 35% upto 20% of replacement of cement with prosopis juliflora ash. For 30% and 40% the optimum water content for the required consistency is increased to 37.5%. This may be due to the hygroscopic character and increased surface area of prosopis juliflora ash which leads to increase the water demand. The setting time of cement paste increases with the increase in percentage of prosopis juliflora ash as replacement of cement. Initial setting time of cement paste at room temperature increases from 32 to 50 min, when replaced by 40%. This is mainly due to the water holding characteristics of prosopis juliflora ash and loss of tri-calcium aluminate from cement which delays the hydration process and increases duration of setting. Besides, prosopis juliflora ash isn't much responsive as cement, which may likewise prompts the expanded setting time of the mixes with the increasing volume of prosopis juliflora ash.

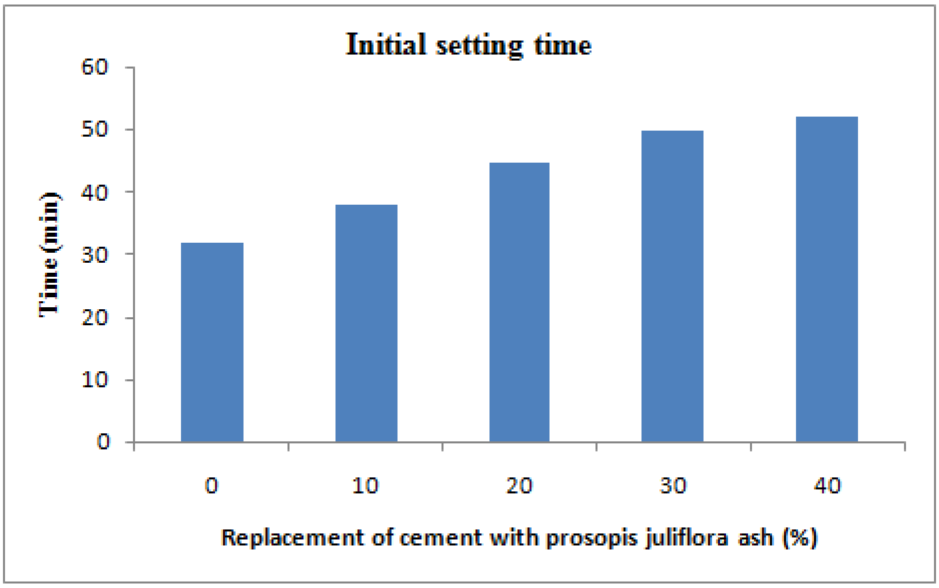

Fig. 1: Initial Setting Time

Soundness test

Soundness test is carried to find the expansion of cement paste at fresh state with the help of using le-chateliers apparatus. The test results showing the variation in expansion of cement paste when cement replaced with prosopis juliflora ash is shown in figure 2. It is observed that with the increase in percentage of replacement of cement with prosopis juliflora ash expansion of cement paste reduces. This is mainly due to the presence of MgO in prosopis juliflora ash. The limit of acceptable soundness as per is4031 is10 mm and the tested results show that all the mixes were inside the acceptable range.

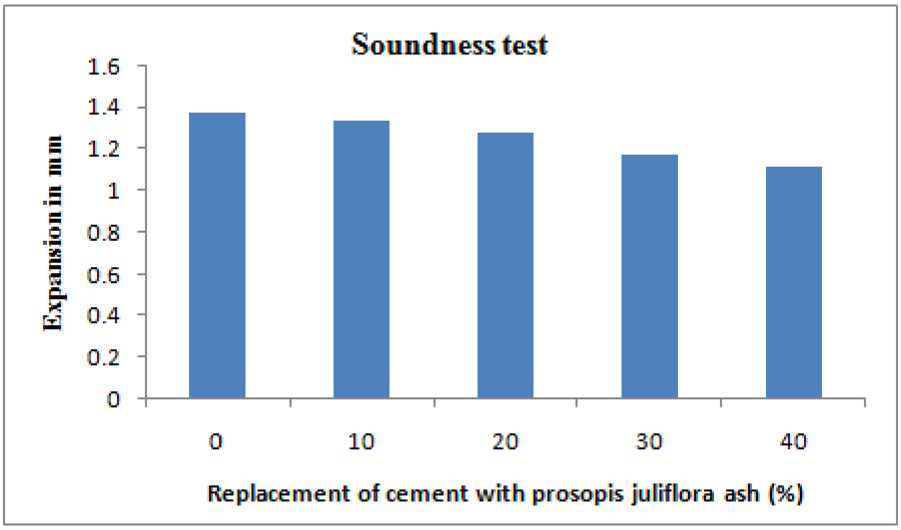

Fig. 2: Soundness Test

Compressive strength

The variation in the compressive strength results of the mortar mixes at 3, 7 and 28 days of curing with variation in the replacement level of cement with prosopis juliflora ash has been shown in Figure. 3. The compressive strength of the cement mortar mix at the age of 3 days curing was observed to be 49 % of its 28 days compressive strength and that of 7 days curing was observed to be 72 % of its 28 days compressive strength. For the mixes with 10 % replacement level of cement with PJA, there was a slight increase in the compressive strength of 6 % compared with the control mix, whereas at 20 % replacement level, it was observed a slight reduction in the compressive strength of 1 % with respect to the control mix. For 30 % and 40 % replacement level, the strength reduction was observed to be 18 % and 29 % respectively with respect to the control mix.

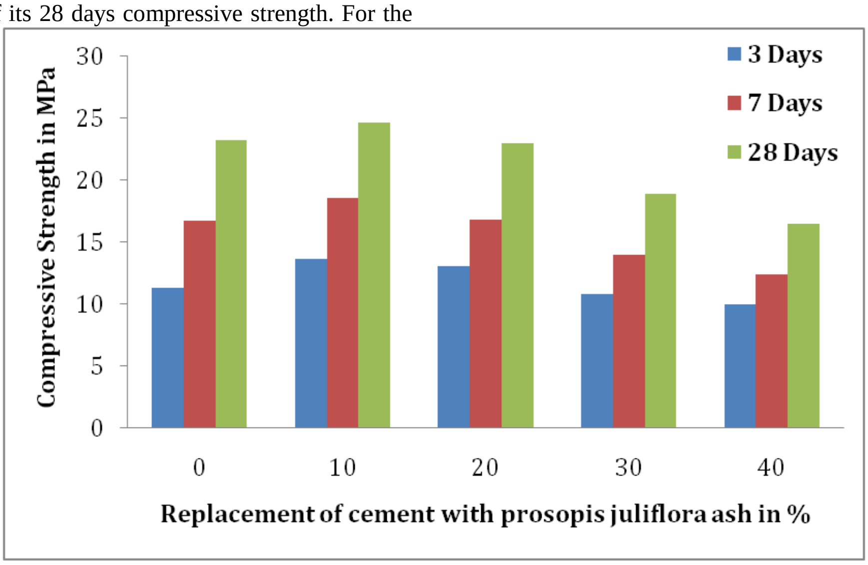

Fig. 3: Compressive Strength of Mortar

4. Conclusion

- The optimum water content required for standard consistency of cement paste is 35% upto 20% of replacement of prosopis juliflora ash after 20% the required amount of water increases to 37.5%.
- With the increase in replacement of prosopis juliflora ash as cement, the initial setting time of cement paste also increases.
- The expansion of cement reduced with the increase in percentage of replacement of prosopis juliflora ash as cement.
- Upto 10% of replacement of cement by prosopis juliflora ash, the compressive strength of cement mortar increases to 6%. Beyond 10% the strength decreases with the increase in replacement. For 30 and 40% of replacement strength decreases by 18% and 29% respectively.

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