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Jarosite added concrete along with fly ash: Properties and characteristics in fresh state ☆

Priyansha Mehra [a,*], Blessen Skariah Thomas [b], Sanjeev Kumar [c], Ramesh Chandra Gupta [c]

[a] *Department of Civil Engineering, Manipal University, Jaipur, Rajasthan, India*
[b] *Department of Civil Engineering, Jaipur National University, Jaipur, Rajasthan, India*
[c] *Department of Civil Engineering, MNIT Jaipur, Rajasthan, India*

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Summary This paper presents the results of different properties and characteristics of jarosite added concrete along with fly ash during its fresh state. Jarosite is an industrial by product from zinc manufacturing industry obtained through hydrometallurgical process from its sulphide ore. It has been tried to incorporate jarosite in concrete as sand replacement. Different concrete mixtures have been prepared for three water—cement ratios (0.40, 0.45 and 0.50) and 5 jarosite replacement levels (0, 5, 10, 15, 20 and 25%). Cement has been partially replaced (25%) by fly ash in all the concrete mixtures. Density, workability and setting & hardening of fresh concrete has been evaluated and analyzed. Keeping the environmental suitability of concrete in mind, toxicity leaching characteristic potential test has been performed on raw jarosite and concrete samples.

Introduction

The new industrial processes have also led to production of large amount of hazardous waste. Metal producing industries is one such sector where several waste materials are generated along with the main products (Thomas et al., 2015). Jarosite is one such by product which is obtained during zinc extraction through hydrometallurgical process in zinc smelters (Ashokan et al., 2006a,b).

Experimental programme

The experimental process is three-step process, including procurement of materials, preparation of concrete samples

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* Corresponding author. Tel.: +91 9828492752.

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Table 1 Concrete mix design.

Series II	Fine aggregate replacement %	Water/cement ratio	Water (kg)	Cement (kg)	Fly ash (kg)	Fine aggregate (kg)	10 mm (kg)	20 mm (kg)	Jarosite (kg)	Super plasticizer (g)
F1	0	0.40	15.2	28.50	9.50	71.300	58.2	58.2	0	304
F2	5	0.40	15.2	28.50	9.50	67.735	58.2	58.2	3.565	342
F3	10	0.40	15.2	28.50	9.50	64.170	58.2	58.2	7.130	418
F4	15	0.40	15.2	28.50	9.50	60.605	58.2	58.2	10.695	494
F5	20	0.40	15.2	28.50	9.50	57.040	58.2	58.2	14.260	570
F6	25	0.40	15.2	28.50	9.50	53.475	58.2	58.2	17.825	646
F7	0	0.45	17.1	28.50	9.50	71.300	58.2	58.2	0	152
F8	5	0.45	17.1	28.50	9.50	67.735	58.2	58.2	3.565	228
F9	10	0.45	17.1	28.50	9.50	64.170	58.2	58.2	7.130	304
F10	15	0.45	17.1	28.50	9.50	60.605	58.2	58.2	10.695	380
F11	20	0.45	17.1	28.50	9.50	57.040	58.2	58.2	14.260	494
F12	25	0.45	17.1	28.50	9.50	53.475	58.2	58.2	17.825	570
F13	0	0.50	19.0	28.50	9.50	71.300	58.2	58.2	0	0
F14	5	0.50	19.0	28.50	9.50	67.735	58.2	58.2	3.565	114
F15	10	0.50	19.0	28.50	9.50	64.170	58.2	58.2	7.130	190
F16	15	0.50	19.0	28.50	9.50	60.605	58.2	58.2	10.695	228
F17	20	0.50	19.0	28.50	9.50	57.040	58.2	58.2	14.260	304
F18	25	0.50	19.0	28.50	9.50	53.475	58.2	58.2	17.825	380

Source: Mehra et al. (2016a,b).

and testing of concrete for determining different properties (Table 1).

In fresh concrete, the density and workability in terms of compaction factor test has been determined.

Compaction factor and density test

Compaction factor and density of concrete has been measured as per IS-1199-1959. The compacting factor test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height.

The density of fresh concrete measured by weighing the cylinder filled with concrete and dividing with its volume. It is expressed in kg/m^3.

Results and discussion

Workability of concrete

The concrete mixture soon after mixing tested for its workability. Workability in terms of compaction factor of concrete mixtures has been tabulated in Table 2.

The compaction factor for all the concrete mixtures (series I & II) has occurred in the range of 0.95—0.98, which can be regarded as quite a good workability. Also, the dosage of superplasticizer has been fixed for each concrete mixture to achieve desired workability (95—0.99).

The reduced water demand in the concrete during mixing may be attributed to presence of fly ash. The spherical shape of fly ash decreases the water requirement in concrete (Neville, 1995).

Table 2 Compaction factor of concrete.

Jarosite (%)	0.40	0.45	0.50
0	0.96	0.97	0.96
5	0.97	0.99	0.97
10	0.97	0.98	0.96
15	0.98	0.97	0.95
20	0.98	0.97	0.97
25	0.96	0.98	0.98

Density of concrete

Density of concrete seems to be reducing with rise in jarosite content. However, the reduction has been observed to be approximately 1% from control concrete to concrete with 25% sand replacement at every *w/c* ratio in both the series. The slight reduction in density can be attributed to addition of filler (jarosite) and mineral admixture (fly ash) having less specific gravity than cement and sand respectively (Table 3).

Setting and hardening of concrete

Freshly mixed concrete, filled, compacted and casted into moulds has been kept for setting up to next 24 h. After 24 h, demoulding has not been possible for jarosite added concrete (excluding control mixtures) due to delay in setting and hardening of concrete. The partially set specimens have broken edges while demoulding. Jarosite concrete got demoulded after next 24 h (48 h after moulding) and cured. The delayed setting and hydration may be attributed to

Table 3 Density of concrete.

Jarosite (%)	Water/cement ratio					
	0.40	0.45	0.50	0.40	0.45	0.50
0	2404	2397	2389	2412	2403	2399
5	2396	2392	2376	2401	2411	2391
10	2387	2386	2366	2397	2395	2388
15	2371	2378	2359	2389	2388	2874
20	2375	2371	2368	2384	2386	2376
25	2385	2364	2371	2381	2379	2375

presence of lead ions in jarosite (21.875 ppm). Previous studies explained the retardation effects in concrete and mortar due to lead on formation of $Ca(OH_2)$ (Asavapisit et al., 1997).

Conclusion

The workability in terms of compaction factor for all the concrete mixtures has occurred in the range of 0.95—0.98, which can be regarded as quite a good workability. Durable concrete can be made with jarosite as a partial replacement for natural fine aggregates & fly ash as binder and it could be applied in practical purposes.

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Conflict of interest

None declared.

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