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Comparative investigation on the influence of spent foundry sand as partial replacement of fine aggregates on the properties of two grades of concrete

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HIGHLIGHTS

- Use of spent foundry sand (SFS) as partial replacement of sand.
- Sand has been replaced with 0%, 5%, 10%, 15%, and 20% SFS.
- Comparative study of the influence of SFS on properties of two grades of concrete.
- Inclusion of SFS in concrete resulted in denser and durable concrete.

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ABSTRACT

An experimental program was carried out to study the influence of spent foundry sand (SFS) as partial replacement for fine aggregates (natural sand) on two grades of concrete mixtures. Two control concrete mixtures (M20 & M30) were designed to have 28-day compressive strength of 30 MPa and 40 MPa. Then, fine aggregate (natural sand) was replaced with five percentages (0%, 5%, 10%, 15%, 20%) of SFS by weight. Comparative performance of both types of concrete (M20 & M30) was investigated by measuring compressive strength, splitting tensile strength, modulus of elasticity, chloride permeability, and ultra sonic pulse velocity up to the age of 365 days.

Test result indicate a marginal increase in strength and durability properties of plain concrete by inclusion of SFS as a partial replacement of fine aggregate. Further, influence of incorporating spent foundry sand is more prominent on M20 grade of concrete as it enhances the strength and durability properties better than M30 grade of concrete.

1. Introduction

Foundry industries utilize high quality silica sand for their molding and casting process. Such industries generate large quantities of by-products of which more than 75–80% of the total by-product material consists of sand. When foundry industries do not use such sands after number of recycling, it is removed from industry, and such sand is called spent foundry sand (SFS). There are two types of foundry sands; green sand and chemically bonded sand. Physical and chemical properties of spent foundry sand depends up on type of casting process, metal being poured, furnaces and finishing process.

Literature research suggests the use of spent foundry sand in highway applications, controlled low-strength materials, hot asphalt mix, and in geotechnical engineering. In this paper, emphasis is on the use of spent foundry sand in concrete. There have been few investigations related to the use of spent foundry sand in concrete [1–14]. In the literature, spent foundry sand is also reported as waste foundry sand (WFS) and used-foundry sand (UFS).

Naik et al. [1] investigated the influence of spent foundry sand on cast concrete products such as brick, block and paving stone. For brick and block, replacement level by mass for sand was 25% and 35%, whereas it was 15% and 25% for paving stone. Naik et al. [2] utilized spent foundry sand along with bottom ash and

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Table 1
Concrete mix proportions with and without spent foundry sand (BIS: 10262-1982) [17].

Mixture No.	Concrete type (M20 grade)					Concrete type (M30 grade)				
	M-1	M-2	M-3	M-4	M-5	N-1	N-2	N-3	N-4	N-5
Cement (kg/m^3)	390	390	390	390	390	450	450	450	450	450
Natural sand (kg/m^3)	569	541	513	484	456	554	527	500	471	443
SFS (%)	0	5	10	15	20	0	5	10	15	20
SFS (kg/m^3)	0	28	56	85	113	0	27	54	83	111
Coarse aggregate (kg/m^3)	1165	1165	1165	1165	1165	1139	1139	1139	1139	1139
W/C ratio	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4
Water (kg/m^3)	195	195	195	195	195	189	189	189	189	189
Super plasticizer (L/m^3)	0.59	0.59	0.59	0.59	0.59	1.65	1.65	1.65	1.65	1.65
Slump (mm)	90	85	85	80	80	120	110	100	95	90

Table 2
Compressive strength of concrete with and without spent foundry sand.

Mixture No.	Concrete type (M20 grade)					Concrete type (M30 grade)				
	M-1	M-2	M-3	M-4	M-5	N-1	N-2	N-3	N-4	N-5
7-Day strength (MPa)	19.7	22.4	24.3	25.3	24.8	26.8	29	30	31.5	30.9
28-Day strength (MPa)	30	34.4	36.8	37.8	37	40	43.3	44.9	46.8	45.3
91-Day strength (MPa)	34.5	38.2	41	41.7	40.8	42.8	45.9	46.7	47.8	46.2
365-Day strength (MPa)	37	40.5	43.6	45	44	46	49.3	52.9	53.5	53

high volume fly ash (25% & 35% of Portland cement) in making precast concrete products. Percentage replacement of natural sand with bottom ash and SFS was 50% and 70%. Test results indicated that these materials could be suitably used in concrete.

Siddique et al. [3–4] concluded that compressive strength, splitting tensile strength, and modulus of elasticity increased slightly with increase in SFS content (0–30%), and these properties also improved with age as well. Etxeberria et al. [5] concluded that concrete made with chemical foundry sand (QFS) as partial replacement (25%, 50%, and 100%) of fine aggregate performed better in workability, and exhibited more compressive strength after high temperature exposure than conventional concrete.

Guney et al. [6] observed that re-usage of spent foundry sand in high strength concrete by replacing natural sand with SFS (0%, 5%, 10%, and 15%), resulted in reduction strength properties, water absorption, void ratio. Singh and Siddique [7–8] have reported that fine aggregate replacement up to 20% with spent foundry sand enhanced the strength properties, durability properties including abrasion resistance.

Monosi et al. [9] explored the possibility of reusing two types of used foundry sands (UFSs), from two different processing stages of the same foundry, in the production of mortars and concretes for structural applications as fine aggregate replacement at increasing dosages (ranging from 0% to 30% by weight). It was concluded that at these percentages of use, mortars and concrete for structural applications can still be manufactured and the use in construction is beneficial over disposal.

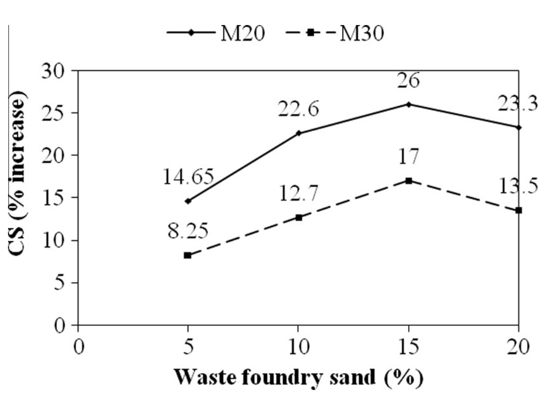

Fig. 1. Compressive strength (CS) verses WFS at 28 days.

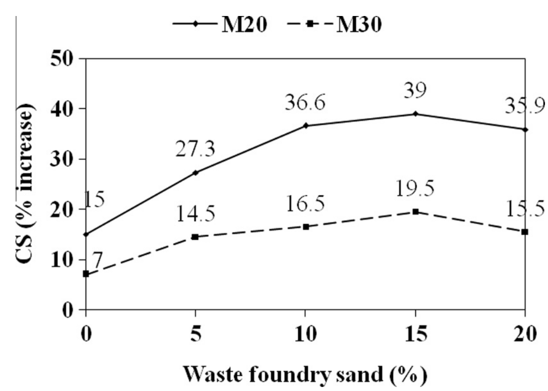

Fig. 2. Compressive strength (CS) verses WFS at 91 days.

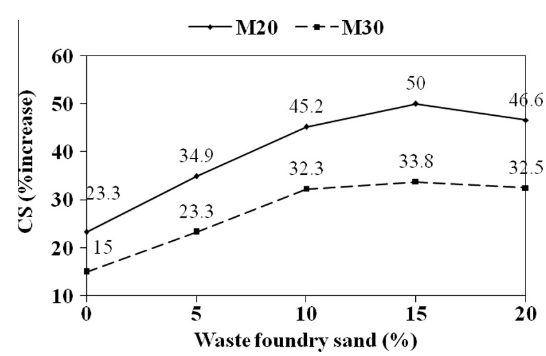

Fig. 3. Compressive strength (CS) verses WFS at 365 days.

Khatib et al. [10] presented the results of an experimental investigation into concrete produced by replacing the fine aggregates (natural sand) with various (0%, 30%, 60%, and 100%) amounts of WFS. The results indicate that there is systematic increase in water absorption by capillary action, a decrease in compressive strength and ultra sonic pulse velocity (UPV) with increasing amounts of WFS in concrete. There seems to be a linear