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ORIGINAL ARTICLES

Experimental investigation of surface modified EOF steel slag as coarse aggregate in concrete

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Abstract An experimental work was carried out to study the effect of Energy Optimizing Furnace (EOF) steel slag as coarse aggregate replacement in concrete. Surface modification of slag was carried out to seal the surface voids of raw slag aggregates. Quarry dust obtained as an extractive waste from the granite stone quarries has been used as a blending material in this work. After several trials, it was found that a mix proportion of 1:6:14 (cement:quarry dust:slag aggregate) was the most suitable mix ratio for the surface modification of the slag aggregates. Various mixes of concrete were prepared with different proportions of modified slag (ranging from 0% to 100%) as replacements for aggregates. Three grades of concrete (20 MPa, 30 MPa and 40 MPa) were used in the investigation and the concrete mixes were evaluated for compressive strength and splitting tensile strength. It was found that the compressive strength improved for 25 percent replacement of natural coarse aggregates. The splitting tensile strength was found to peak at 25 percent replacement of natural aggregates.

1. Introduction

Presently, there are various methods for production of steel and the EOF is relatively a recent technique employed to manufacture steel from iron ore. The produced steel slags contain EOF slag. Earlier researchers have utilized other types of steel slag as both fine and coarse aggregate replacement successfully in concrete. Brand and Roesler (2015) have utilized different basic steel slags as aggregates and also carried out tests to evaluate the chemical and mineralogical properties. Adegoloye et al. (2015) have successfully utilized Electric Arc Furnace (EAF) slag and Argon Oxygen Decarbonization (AOD) slag as aggregates. Numerous studies were carried out with EAF slag as replacement for coarse aggregates (Muhumood et al., 2009; Abu-Eishah et al., 2012; Alizadeh et al., 2003; Manso et al., 2006). The instant chilled steel slags were experimented to be a suitable replacement for natural coarse aggregates in concrete (Montgomery and Wang, 1991). The study majorly

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Table 1 Composition of EOF slag and EAF slag.

Compound	EOF slag (%)	EAF slag (%)
CaO	36.96	20–40
FeO	28.93	20.40
SiO_2	13.81	6–23
MgO	7.46	3–15
Al_2O_3	2.53	3–14
MnO	3.00	1.5–15
P_2O_5	1.58	–
TiO_2	0.60	–
Na_2O	0.057	–
K_2O	0.032	–
Loss on ignition	3.70	–

focused on the strength properties of concrete with steel slag aggregates. Wang (2010) studied the feasibility of adopting steel slag coarse aggregate in concrete by determining the expansive force of the steel slag aggregates. Durability properties were also studied extensively to evaluate the performance of steel slags in concrete (Manso et al., 2006; Luxan et al., 2000).

It was found that the steel slag is volumetrically unstable as compared to the blast furnace slag due to the presence of expansive oxides (CaO/MgO) (Wang, 2010). The chemical composition of EOF steel slag was observed and it was found that the properties vary from other steel slag properties. The chemical properties of EOF slag are listed in Table 1. It was observed that it contains 36.96% of Calcium Oxide (CaO) which in the presence of water undergoes hydration to calcium hydroxide ($Ca(OH)_2$) resulting in volume expansion leading to cracking. Surface modification of slag can seal the passage to the inner core of slag aggregate and can reduce the hydration considerably.

As natural resources are fast being depleted to satisfy the ever increasing demand for them, much emphasis has been laid on utilization of extractive wastes in construction practices. Since the EOF steel slag is a recent technique adopted in the steel manufacturing industry, research is required to be carried out to study the feasibility of its adoption as aggregates in concrete. This work focuses on the study of compressive and splitting tensile strength of concrete for three different grades of concrete (20 MPa, 30 MPa and 40 MPa) with EOF slag aggregate as replacement to stone aggregates in concrete. The EOF slag aggregates were blended with slurry of cement and very finely sieved quarry dust.

2. Materials

2.1. Cement and aggregate

Ordinary Portland Cement (OPC) conforming to IS: 12269-(1987) with a specific gravity of 3.15 and potable water was used for production of concrete. The fine and coarse aggre-

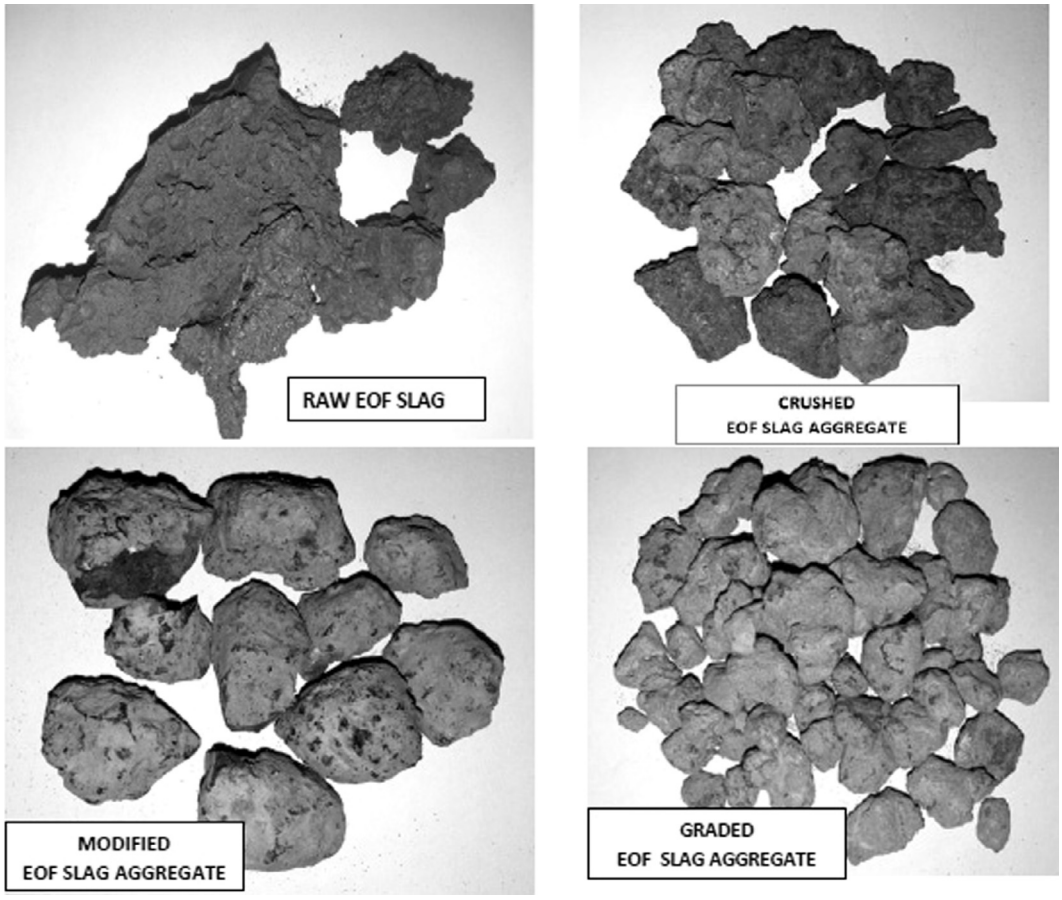

Figure 1 Raw and modified EOF slag.