Properties of cement concrete with Imperial smelting furnace slag as replacement of sand

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This paper reports the results of replacing sand in cement concrete using imperial smelting furnace Zinc slag. The fine aggregate fraction so produced conformed to the grading requirements of both fine aggregate and all in aggregate. The workability of concrete improved as the replacement level increased, though the packing density of the dry all-in aggregate reduced. Replacing sand with zinc slag did not affect the compressive strength, but in a leaching test, complete replacement resulted in Lead (Pb) setting leached above the permissible level.

Keywords: ISF slag, packing density, compacting factor, compressive strength, leaching

Aggregates constitute about 70% of the volume of concrete. While natural fine aggregates are quarried from riverbanks, coarse aggregates are derived by quarrying and crushing rock deposits. Increasing demand of concrete for construction is depleting such sources of aggregates and resulting in environmental degradation. Hence, suitable replacement for natural aggregates is a step towards sustainability. As a result, research work on replacing aggregates in concrete is increasing with such materials as recycled aggregates from demolition wastes, bottom and ponded ashes from power plants, incinerator ashes and slags from ferrous/non ferrous metal extraction.

Zinc extraction by pyrometallurgical process in Imperial Smelting Furnace (ISF) results in slag generation in large quantities. The hydraulically quenched granular slag, bearing Lead and Zinc, has a grain size comparable to that of the fine aggregate in concrete. However, the presence of these heavy metals makes it a hazardous material because leaching of these metals could contaminate the soil and ground water.

Solidifying or stabilizing leachable metals such as Zinc (Zn) and Lead (Pb) in a cement matrix is a proven technique in hazardous waste management. In the past, researchers have tried to use ISF slag as aggregates in cement concrete. Sujita et al. have reported that concrete made with Zn slag fine aggregate resulted in a compressive strength that was comparable with that of the reference concrete. Atzeni et al also obtained comparable compressive strengths in three mixes that had ISF slag, up to 25%, as a sand replacement material. The mixes were a rich cement concrete (W/C ratio=0.43), a lean cement concrete (W/C ratio = 0.8) and a fly ash mixed cement concrete (W/C ratio = 0.45). Apart from giving the strength related data, the study also reported that the elution of Pb from ground samples of the concretes in acidic solutions (pH <5) was above the permissible levels (5 ppm) for all three types of concretes. Morrison et al have reported delayed setting of concrete on partial (50%) and complete (100%) replacement of sand by ISF slag in cement concrete with