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EXPERIMENTAL STUDIES ON STEEL SLAG IN CONCRETE

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ABSTRACT: *By means of orthogonal design, this study replaces sand with the steel slag and slags of Handan to compare the concrete made of steel slag and slag with ordinary concrete. The results show that compressive strength of concrete with the mixture of steel slag is very close to that of ordinary concrete on the 7th day and 28th day respectively. The volume of steel slag and water-cement ratio and the comparison between the amount of slag and that of cement show that steel slag content influences the slump of concrete the most.*

Keywords -- Slag, Steel, Concrete, Aggregates, Production, Testing, Design engineering, Iron, Mechanical factors, Design optimization

1.INTRODUCTION

Steel slag was existed as by-product during melting of steel scrap from the impurities and fluxing agents, which form the liquid slag floating over the liquid crude iron or steel in arc or induction electrical furnaces, or other melting units. The properties and chemical composition of the slag were stated by Clarkson University, the specific gravity ranges from (2.85-3.0) and bulk density varies from (1.0-1.4 gm/cm3. The active slag made from molten iron has to be water cooled. Chemical composition of typical slag consisted mainly SiO2, Al2O3, CaO and Fe2O3. The slag may be further processed after cooling, mainly crushed and screened to desired size, prior to being used or sold. The main uses of steel slag were in road bases and surfaces concrete, asphaltic concrete and as aggregate in hydraulic cement concrete. In the past 20th century, slag was found to be excellent aggregate for asphalt road paving. Different forms of slag produced depend on cooling method used. It may be used as a mineral admixture for Portland cement concrete. Work was done in Germany to develop an injection mortar based on furnace slag, gypsum and Portland cement. Various results were obtained by using furnace slag for oil field by different test in the (Fluid Research Association Laboratory). Another investigation carried out at the King Fahd University, to determine the role of chloride ions in sulphate attack in plain and blended cements. The results indicated that sulphate deterioration in plain cements was mitigated. Studies conducted at MC Master University in Hamilton, dealt with the fact that when steel slag is used as aggregate, its properties depend on its chemical and mineralogicalcompositions. The latest development in the disposal and application on iron and

steel slag in Japan were described at Shanghai Institute of Metallurgy. Suchdevelopments included the air granulated slag process, ultra fine furnace slag, color sand, recovery of the useful constituents in steel slag. Other uses of steel flag are four water penetrating and anti-wear material for pavement, spray abrasives for grinding ship surfaces and water purification agents.

2.UTILIZING WASTE MATERIALS AS CONSTRUCTION MATERIALS

The United States of America had been one of the earliest nations utilizing waste and recycled materials in the construction field. These efforts were continuously documented since decades ago. A recent report entitled 'Transportation: Leading in Recycling' (AASHTO, 2003) reported the following efforts by various road authorities in the United States on the matter of utilizingrecycled materials in road constructions:The Texas Department of Transportation (TxDOT) had spent more than USD506 million on 'green products' and diverted more than 13 million tons of materials from the landfill since launching its recycling program in 1994.Pennsylvania Department of Transportation (PennDOT) started the Strategic Recycling Program as a comprehensive effort to systematically identify, evaluate, and implement recycling opportunities throughout Pennsylvania. They also worked in hand with the state Department of Environmental Protection to reduce waste materials from transportation operations and to encourage use of recycled materials throughout transportation applications in the state.The Massachusetts State Transportation Agency (Mass Highway) reported an impressive statistics, including recycling more than 15,000 tons of waste and more than 111,000 tons of recycled materials were used in construction projects. Overall, nearly USD 27 million was spent on recycled-content and environmentally preferable materials and products. The California Department of Transportation (Caltrans) recycled asphalt and concrete pavement by converting it into base and sub-base under the new road surface, and at the same time the agency is looking for new ways to use recycled materials in road surfaces.

3.OBJECTIVES

The aim of this research is to study the performance of steel slag as concrete as coarse aggregates compared to the conventional use of granites for the same purpose. The detailed objectives are outlined below:

To assess the performance of dense cement mix prepared using 100% steel slag (SSDA) and dense cement mix incorporating a combination of 50% granite and 50% steel slag (SSGDA).

To evaluate the effect of moisture, temperature and aging on the performance of mixes incorporating steel slag.

4.SCOPE OF WORK

The scope of work for this research is to develop cement mixes compatible or out performing existing conventional concrete mixes, using steel slag and a combination of 50% steel slag and 50% granite as aggregates. The mix type investigated was a dense mix confirming to the JKR ACW14 gradation using 100% steel slag (SSDA), 100% granite (GDA) and combination of 50% steel slag and 50% granite (SSGDA). The performance of GDA stated in this study was obtained

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from Mohamed (2007) and used as a comparison to the performance of SSDA and SSGDA. Besides, porous mixes confirming to the gradation developed by Samat (2006) using 100% steel slag (SSPA) and 100% granite (GPA) were also studied. For porous mixes, the binder type used was penetration grade 60/70. Steel slag aggregates were obtained from the Natsteel plant at the Prai Industrial Area. These aggregates were selected from two different stockpiles of coarse aggregates (> 10mm) and fine aggregates (< 10mm). These aggregates were then crushed and sieved into their designated bins. A range of tests was carried out to evaluate the mix properties and performance, including obtaining volumetric properties, the optimum binder content, stability, potential of cracking and permanent deformation, susceptibility to moisture, water permeability and abrasion loss. These testing procedures were repeated for specimens subjected to accelerated ageing process in a force draft oven to evaluate their performance under service. The test results of mixes incorporating steel slag aggregates were then compared with those of conventional mixes.

NEED FOR STUDY

Steel slag aggregate is a 100% recycled and engineered product with great potential as replacement to naturally occurring aggregates in construction projects due to its physical and chemical properties. Most projects involving steel slag aggregate were incorporating this aggregate type in lower quality applications. However, steel slag aggregate was reported to exhibit higher porosity, superior adhesion with binder due to its surface structure and chemical content, and favorable shapes. From the economic point of view, utilization of steel slag as aggregate for concrete may reduce the cost of extracting and processing naturally occurring aggregates. The steel producing industry may also reduce their cost for treating and disposing the vast number of steel slag stockpiles. On its impact at preserving the environment, utilization of steel slag aggregate in various ways may directly reduce both the dependent on naturally occurring aggregate and the number of raw material-extracting projects. The steel slag is used as aggregates. Natural aggregate resources are becoming more difficult to develop or remove aggregate from the ground when slag can be used as a substitute which reduce waste and conserve resources. It protects and preserves our environment. Benefit from technical advantages offered by many of the steel making slag. High performance products not necessarily low grade applications

5.CONCLUSIONS

- Test results shows that, for M30 grade 40% replacement of steel slag increases the compressive strength of 40.8 N/mm2 and for M40 grade 40% replacement of steel slag increases the compressive strength to a maximum of 46.3 N/mm2.
- For M30 grade above 40% replacement of steel slag reduces the compressive strength drastically, may be due to the water-cement ratio. Similarly for M40 grade more than 40% replacement of steel slag has reduces the compressive strength of concrete.
- Comparing SSC of M30 grade and M40 grade shows much good result for M30 grade of concrete. This may be due to the bond strength, aggregate interface and water-cement ratio.

• The split tensile strength of the SSC concrete for 40% replacement of coarse aggregate with steel slag was tested for 7 days and 28 days were given better results when compared to the concrete specimens.

• Similarly flexural strength of SSC at 40% replacement of coarse aggregate, performs very well than the control concrete. The results gives much increase strength for SSC better than the control concrete.

• These results encourage the use of steel slag for the partial replacement material for high strength concrete.

• The equation analysis for the determination of compressive strength of SSC for various replacement of steel slag for both M30 and M40 grade has been enhanced.

• A generalized equation has been determined from the previous equation analysis which is suitable for both M30 and M40 grades of concrete.

• The results were compared with the journal 'Broader use of steel slag aggregates in concrete' by Jigar patel. The results were shown a maximum strength improvement of 16% at 40% replacement.

• The comparison of present experiment results with literature study has been shown as line chart and the literature study have gave better results when compared with the present experiment.

• By executing the best fit line for the present results, generalized equation for the percentage improvement for compressive strength of steel slag has been derived.

• This equation gives results for compressive strength of SSC for a particular replacement percentage of steel slag.

Hence from the results it is noticed that that eco friendly concrete made with optimum steel slag shows superior strength properties compared to the control concrete. So these steel slag can be enhanced and used for partial replacement material for coarse aggregate in concrete preparation. Also eco friendly concrete reduces the impact of pollution in atmosphere and hence save the environment, to lead a better life.

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