ABSTRACT

Solid waste management is the prime concern in the world to-day. Due to non-availability of dumping space and land – filling area, utilization of industrial wastes in construction sector has become an attractive proposition to disposal. Acceptance of industrial waste/by-products as raw materials in concrete making has encouraged researchers in evaluating and exploring technologies. Utilization of industrial waste/by-products in concrete strengthens economy as well as ecology.

Ferro Alloy industry is one of the industries producing huge quantity of wastes in form of ferrochrome ash & ferrochrome slag. Ferrochrome ash is the dust obtained from gas cleaning plant of Ferro alloy industries. The gas emitted from Ferro- alloy smelting furnaces contain particles of dust, dirt and incompletely combustion wood and/or coal and coke. Gas cleaning plant cleans above gases and during this process huge quantity of dust is collected which is named as ferrochrome ash (FA) in this research. Ferrochrome slag is obtained as a waste material by smelting process during the production of stainless steel. Global annual production of ferrochrome is around 6.5 to 9.5 million tons. The same is increasing at the rate of 2.8% to 3% per year. It is reported that generation of solid waste for each metric ton (MT) of ferrochrome product is about 1-1.2 MT. Odisha itself has nine numbers of Ferroalloy industries. Solid wastes from these industries are also increasing day by day. Not only these have occupied valuable space but also threatening the aquifer. Disposal and utilization of ferrochrome waste is one of the subjects essentially addressing the recent research interest. Use of ferrochrome waste in concrete making is investigated in this research work considering the requirement of ferrochrome waste disposal.

Current investigation has explored possibility on use of (i) ferrochrome ash along with lime for partial replacement of cement (ii) ferrochrome slag as coarse aggregate replacing the natural coarse aggregates for preparation of concrete.

Ferrochrome ash contains 19.6% of SiO₂, 11.1% of Al₂O₃, 15.6% of MgO & 4.22% of CaO. It satisfies the requirements of slag as per IS: 12089-1987 and can be used as a pozzolanic material for replacement of cement. Similarly Ferrochrome Slag contains 27.5% of SiO₂, 24.7% of Al₂O₃, 22.5% of MgO & 9.06% of CaO and can be used as coarse aggregate replacing the natural coarse aggregates for preparation of concrete.
Initially experimental investigation was performed to study the effect of lime on mechanical and durability properties of concrete made from blended cement like Portland slag cement (PSC) & Portland pozzolana cement (PPC) using natural coarse aggregate. Various % of lime such as 0%, 5%, 7% & 10% was added to PSC & PPC in form of cement replacement. It was observed that at 7% of lime replacement, there is increment of compressive & Flexural strength in comparison to replacement at other percentage. Durability properties such as resistance to acid attack and sulphate attack in terms of strength loss and weight loss also improved. Both the concrete mixes (PSC & PPC) were also observed sound at replacement of 5-10 % lime by Lee-Chatelier apparatus. However water demand increased, setting time & workability decreased, which could be managed with addition of super plasticizer.

Further investigation is carried out on mechanical and durability properties of concrete at 7% of lime replacement in PPC and PSC using ferrochrome slag as aggregates with 100% replacement of natural coarse aggregates. Improved mechanical and durability properties of concrete are observed. It is noticed that concrete mixes containing ferrochrome slag aggregate exhibited more strength in comparison to concrete containing natural coarse aggregate.

Concrete made from ordinary Portland cement (OPC) with partial replacement of cement in various percentages like 0%, 10%, 20%, 30% & 40% of ferrochrome ash along with 7% lime containing natural fine and coarse aggregate on a nominal mix proportion was examined. It is found that, due to inclusion of ferrochrome ash and lime mechanical (compressive strength, flexural strength, splitting tensile strength, bond strength & modulus of elasticity) and durability properties (acid resistance, sulphate resistance, water permeability and abrasion resistance) of concrete increases at all ages. Results revealed that, quality of concrete containing ferrochrome ash and lime improved in terms of density and homogeneity. At 47% replacement of cement, 40% by Ferrochrome ash and 7% by lime, the strength of normal concrete or even more is achieved at all ages.

Effect of 47% of cement replacement, 40% by ferrochrome ash and 7% by lime was examined on compressive strength of concrete on various mix proportions such as (1:2.5:5), (1:1.5:3.5), (1:1.5:3), (1:1.3:3) & (1:1:2.5). Test results revealed that mixes containing 40% FA and 7% lime exhibited strength of normal concrete or even more at all ages. Hence it is
reported that 47% of cement replacement, 40% by ferrochrome ash and 7% by lime is possible on different mix proportions also.

Effect of 47% of cement replacement, 40% by ferrochrome ash and 7% by lime was examined on flexural behaviour of structural member like beam. The beam capacity, its failure and crack pattern were studied and found similar or even better performance than the beam of control concrete.

Concrete made from OPC blended with ferrochrome ash in various percentages such as 0%, 10%, 20%, 30% & 40% along with 7% lime on replacement of cement, containing ferrochrome slag aggregates by replacing natural coarse aggregate was investigated. Due to inclusion of lime, ferrochrome ash & ferrochrome slag as coarse aggregate there was high increase in early age mechanical properties and durability properties. Concrete mix at highest replacement of cement, containing 40% ferrochrome ash, 7% lime & ferrochrome slag aggregate exhibited more strength & durability properties in comparison to control mixes containing ferrochrome slag aggregate at all ages. Concrete mixes containing ferrochrome slag as coarse aggregate showed more strength & durability properties in comparison to mixes containing natural coarse aggregate at all ages. Non-destructive tests such as rebound hammer and ultrasonic pulse velocity tests were conducted at the age of 28, 91 & 180 days.

Flexural behaviour of RCC beam containing ferrochrome slag as coarse aggregate and ordinary Portland cement with 47% of replacement in form of 40% ferrochrome ash and 7% lime was examined. It has been observed that inclusion of ferrochrome ash, lime and ferrochrome slag as aggregate in concrete shows better flexural capacity of beam in comparison to beam using normal concrete.

Regression analysis was carried out to establish correlation between strength, durability and non-destructive properties. It was observed that there is a good correlation between these properties. The value of correlation coefficient of concrete containing lime, ferrochrome ash, natural coarse aggregate and ferrochrome slag aggregate at all ages between strength properties varied from 0.747 to 0.993, between strength and non destructive properties varied from 0.872 to 0.996, between durability properties varied from 0.894 to 0.999 and that of between strength and durability properties varied from 0.732 to 0.996. The high values of correlation coefficient indicate strong relationship between different properties.