USE OF STEEL SLAG IN CONSTRUCTION OF FLEXIBLE PAVEMANT

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ABSTRACT

The large amount of Industrial wastes as increased year by year and disposal becomes a very serious problem. It is necessary to utilize the steel slag waste affectively with technical development in each field. Commonly murrum soil has been used for construction of all categories of roads in our country. Although murrum is a good construction material, due to scarcity they increase the construction cost at some parts of the country, several types of murrum soils are found to be unsuitable for road construction in view of higher finer fraction and excessive plasticity properties. Such as used industrial material like steel slag in construction of road pavement. Its disposal causing severe health and environmental hazards in road construction industries is gradually gaining significant importance in India considering the disposal, environmental problems and gradual depletion of natural resources like soil and aggregates. Steel slag is a waste material generated as a by-product during the manufacturing of steel from steel industries. The quantity of generation is around 24 lacs MT per year from (Ref.Report.CRRI-2010) different steel industries in the India. Presently, it has no applications and dumped haphazardly on the costly land available near the plants. In this study, a typical steel slag was collected from an M/s Jindal Steel Iindustry Pvt.Ltd Sinnar MIDC, (M.S) in India and its feasibility for use in different layers of road construction was investigated. To improve its Geotechnical engineering properties, the Steel Slag material was mechanically stabilized with locally available soil in the range of 5 – 25%. Geotechnical parameters of these stabilized mixes were evaluated to investigate their suitability in the construction of different layers of road Technical specification of steel slag is developed for utilization in the construction of embankment, sub grade and sub base layer of Flexible pavement.

INTRODUCTION

The iron and steel slag that is generated as a byproduct of iron and steel manufacturing processes can be broadly categorized into blast furnace slag and steel making slag. Blast furnace slag is recovered by melting separation from blast furnaces that produce molten pig iron. It consists of non-ferrous components contained in the iron ore together with limestone as an auxiliary materials and ash from coke. Depending on the cooling method used, it is classified either as air-cooled slag or granulated slag. Steel making slag consists of converter slag (Basic oxygen furnace slag) that is generated by converter and electric arc furnace slag that is generated during the electric arc furnace steel making process that uses steel-scrap as the raw material.

Large quantities of natural materials are traditionally used in road construction. Uncontrolled depletion of natural, non-renewable resources leads to environmental destruction and distortion of natural balance. Concurrently the world faces the problem of management of an increasing quantity of waste, so that linking the two problems leads to a simple solution: a growing and more diverse application of waste materials in road building and other areas of civil engineering alike. Waste materials whose application is possible in road construction are divided into three basic groups: re-usable construction materials, industry by-products and natural construction materials of a lower usability value [ ]. The first group includes the materials that were used one or more times, such as materials from unbound base courses (gravel, sand, and rock) and materials from bitumen and hydraulically bound layers. Slag and fly ash belong to the group of industry by-products, whereas the group of natural construction materials with lower usability value is primarily represented by excavation materials and quarry waste.

Slag production method

Slag is a waste material generated in purifying metals, their casting and alloying. In the course of this process, slag is generated in two phases. In the first phase the ore is exposed to high temperatures (melting) in order to separate impurities. Separated impurities are collected and removed, and this "waste" material is called slag. During further processing of metal (casting, alloying) various substances are added to purified metal which melt it and enrich it, and in those processes slag is generated again as a by-product. The type of generated slag depends on the method of cooling of the melted mass (Fig. 1) and on the type of processed metal (non-ferrous and ferrous slag). Crystalline slag has cellulose or porous structure (the result of gas bubbles generated in the melted mass) and is usually considered to be in the group of aggregates with normal weight. In the production of granulated slag sand-sized grains are created. Due to its composition, this material has excellent hydraulic properties, and in the presence of an appropriate activator (such as calcium hydroxide) will behave in a manner similar to Portland cement. Expanded or foamy slag is more porous and has a smaller volume than air cooled slag.

Basic properties of steel slag

Steel slag is generated as a by-product in the production of a specific type of steel from melted iron. This procedure of steel production is carried out according to one of the three procedures known so far: the one in basic oxygen furnace, procedure of processing in electric arc furnace and nowadays mainly abandoned procedure in open-hearth furnace. In each of the three procedures the furnace is filled with hot and/or cold metal and additives to obtain steel with desired characteristics. Then the melted steel and impurities are separated from the furnace, with the impurities consisting mainly of carbon monoxide and silicon, manganese, phosphorus, and some iron in the form of liquid oxides. Combined with lime and dolomite lime, those impurities create steel slag mostly cooled naturally – air cooled – or cooling can be accelerated by sprinkling water. The names of slag originate from the procedure in which the slag was generated (Fig. 2), but very frequently all types of slag are simply called steel slag.

Like the name, the composition of this material depends on the procedure in which it was generated, composition of steel additives and the very type of steel being produced and the cooling speed. In the composition of steel slag there is a significant share of free calcium and magnesium oxides which are considered responsible for the biggest lack of this material and its limited usage in road building. Namely, steel slag is very expansive, and due to this reason the volume can change by as much as 10 % (free oxides of calcium and magnesium under the influence of humidity hydrate, causing large changes of volume) Slag weathering in atmospheric conditions is considered to be one of the most appropriate methods of eliminating this adverse property. The weathering period varies depending on the application method and the type of slag itself, i.e., the quantity of free calcium and magnesium oxides. Therefore, it sometimes takes only several months of weathering in atmospheric conditions or occasional sprinkling with water According to Belgian and Dutch regulations for the use of slag in unbound base courses one year of weathering is sufficient, whereas there are known data on the need for weathering for as much as 18 months before using the slag as aggregate. Those big changes of volume limit the use of steel slag in rigid pavement however, they can be controlled (in asphalt mixtures), or even used as improvement of the properties of built-in material in shoulders or non-asphalt parking areas. The presence of free calcium oxide, accounting for more than 1 %, causes another adverse property of steel slag, namely, the appearance of white powder in the form of sediment. Free CaO from leachate is bound with water, creating calcium hydroxide, Ca(OH) , which, when exposed to atmospheric conditions, reacts with carbon dioxide, CO creating calcium carbonate (CaCO) [5]. It settles down in the form of white powder and may cause obstructions in the drainage systems and water retention. Those obstructions are particularly dangerous in the case of freezing, which renders large damage to pavement structures. This, however, unlike expansions, cannot be prevented by slag weathering. Among other characteristics two should be stressed – a big bulk density of steel slag and unit weight of 1600-1920 kg/m . The grains of this material are pointed, with rough surface, and this is particularly suitable in case of use in asphalt mixtures for reason of an increase in adhesiveness between the pavement and the wheels. The big angle of internal friction (40°-45°) contributes to big stability of materials and CBR value of up to 300 % [5]. Steel slag belongs to medium alkaline materials, with pH values of 8-10.

GEOTECHNICAL CHARACTERISATION OF SLAG, LOCALLAY AVAILBALE SOIL AND THEIR MIXES

The geotechnical characteristics of Steel Slag Locally Available Soil and their mixtures were investigated to study their feasibility in different layers of road pavement. Construction of road embankment using slag alone would not be feasible as it is cohesion less material. Such embankments would be highly erodible. Therefore, it was blended with local soil in the range of 25-75 % and their geotechnical characteristics were investigated. Different mix proportions with their corresponding mix designations blending of slag and soil – slag and soil were blended manually as per percentage by weight in the laboratory for investigation. Important geotechnical characteristics namely Index Properties like Specific Gravity, Moisture Absorption Test, Grain Size Analysis, Atterberg limit, Modified Proctor compaction Test, CBR Test. were carried out. Based on the results, potential mixes were selected for embankment fill, sub grade and sub base applications

Table 1 Mixes and their Mix Designation

Mix Designation	Mixes
100LS	100% Local soil
5S+95LS	5 % Steel Slag + 95 % Local Soil
10S+90LS	10 % Steel Slag + 90 % Local Soil
15S+85LS	15 % Steel Slag + 85 % Local Soil
20S+80LS	20 % Steel Slag + 80 % Local Soil
25S+75LS	25 % Steel Slag + 75 % Local Soil
100S	100% Steel Slag

EXPERIMENTAL WORK

- ***Specific Gravity Test***

Specific gravity test was carried out as per IS 2720 Part 3 (1980). Specific gravity of steel slag and local soil was observed to be 4.28 and 2.10 respectively.

- **Grain Size Analysis**

Grain size analysis was carried out of slag and local soil as per IS 2720 part 4 (1985). Slag and local soil samples were observed to be coarse grained materials. Slag was crushed by roller and grain size analysis was also carried out. Cu and Cc Values find out.

Table-2.Values of Cu and Cc

Coefficient of uniformity (Cu)	12.87
Coefficient of curvature (Cc)	1.94

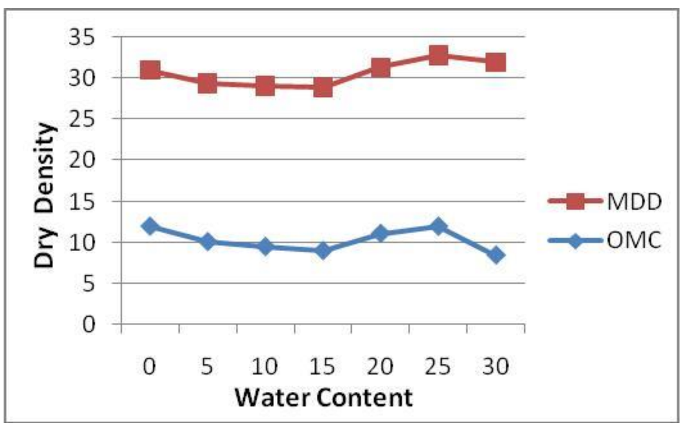
- **Atterberg Limit Test**

Atterberg limit test was carried out as Part 5 (1985). Oven dried samples (Passing 4 micron) were used to determine the Liquid Limit (LL) and Plastic Limit (PL). Slag and their mixes were observed to be non plastic in nature. The Liquid Limit (LL) and Plastic limit (PL) of local soil were determined as 51% and 29% respectively.

- **Moisture Absorption Test**

To know the voids in slag, moisture absorption test is carried out as per BIS 2386 Part 3 (1997). Moisture absorption value of Steel Slag was obtained as 10%.

Type of Mix	OMC (%)	MDD (KN/m^3)
100LS	12.0	19.00
5S+95LS	10.10	19.30
10S+90LS	9.50	19.63
15S+85LS	9.00	19.90
20S+80LS	11.12	20.20
25S+75LS	12.00	20.80
100S	8.45	23.50



- **California Bearing Ratio Test**

California Bearing Ratio (CBR) test was carried out as per IS: 2720-Part 16 (1979). Samples were compacted statically compacted in the CBR mould at its corresponding optimum moisture content to achieve maximum dry density. CBR values of slag and local soil were tested optimum mixes find respectively. Variation of CBR values with Curing Period :It was found out that the CBR values of both the mixes increased with the increase in curing period. From the load penetration curves after applying the corrections the CBR value of Locally Soil and Steel slag was found to be 5. The tests were then conducted on the Three optimum mixes i.e. 15S+ 85LS, 20S+80LS,25S+ 75LS. and find variation of CBR for the given curing period. The samples were first cured in humidity chamber at 30 degree temperature and 85% relative humidity for a period of 0, 7, 14, days and then soaked in water for 4 days prior to testing

CONCLUSION

The feasibility of utilizing of Steel Slag and Local soil in construction of flexible pavement with variation of Percentage in soil. The following conclusions have been drawn. Application of slag as an alternative to standard materials in the world has been known for a number of years, and accordingly numerous research studies have been carried out in that area. Slag is used the most in asphalt mixtures, although its good properties are also used for application in other layers of pavement structure, primarily unbound base courses and embankment. An area of application that has not been studied extensively so far is the application of slag in stabilized mixtures for construction of base courses, which could be of great interest for domestic road construction. Namely, in the last ten years road building in the Republic of Croatia was based on motorway building, and in this process, given the very heavy traffic load, cement-bound base courses were designed to increase the bearing capacity. Domestic slag has a significant quantity of calcium oxide, CaO (25-30 %, whilst free CaO accounts for 0,22-0,28 %), which is the basic indicator of pozzolanic behaviour of the material

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