A REVIEW ON USE OF STEEL SLAG IN ASPHALT ROAD CONSTRUCTION

Bandagi Sab[1], Chandan P[2], Chetan Shidagouda Mudalgi[3], Harshavardhan M[4], Vinay A[5]

[1-4]Students, BE, Department of Civil Engineering, DSCE, Bangalore, Karnataka, India.
[5]Professor, Department. of Civil Engineering, DSCE, Bangalore, Karnataka, India.

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. This project was intended to study the effectiveness of using steel slag aggregate (SSA) in improving the engineering properties of locally produced asphalt concrete (AC) mixes. The research started by evaluating the toxicity and chemical and physical properties of the steel slag. The AC mixes was replaced by SSA. The effectiveness of the SSA was judged by the improvement in indirect tensile strength, resilient modulus, rutting resistance, fatigue life, creep modulus, and stripping resistance of the AC samples. The ductility of bitumen containing steel slag aggregates firstly increases then decreases with increasing in percentage of steel slag aggregates in mix. The test result showed a significant scope of use of steel slag, along with the bitumen as a binder.*

***Key Words*: Steel Slag Aggregate (SSA), Asphalt Cement (AC), Blended fillers, Marshal Stability Test (MST), Rutting Failure Test (RT).**

1. INTRODUCTION

1.1 General

Asphalt concrete is a commonly used material in the roads construction industry; thanks to its seamlessness, economical cost, easy to repair, high driving comfortability, and lower noise. Currently, the consumption of bitumen (i.e. binding material in asphalt concrete) is increasing dramatically due to the high demand for road construction as a result of the development of infrastructures. Such massive use of bitumen raises the concerns of environmental pollution, ecological imbalance, and harmfulness to human health.

The iron and steel slag that is generated as a by-product of iron and steel manufacturing processes can be broadly categorized as blast furnace slag and steel making slag. Blast furnace slag is recovered by melting, separation from blast furnace that produce molten pig iron. It consist of non-ferrous components contained in the iron core together with limestone as an auxiliary materials and ash from coke.

Steel making slag consist of converter slag (basic oxygen furnace slag) that is generated by converter and electric arc furnace steel making process that uses steel scrap as a raw material. In the present study, solid waste which is generated as a buy product which is generated during the melting process of mixed materials which are steel scrap, pig iron, silico-manganese, sponge iron and al-shots is turned as granulated blast furnace slag. The waste material is neutral and non-hazardous in nature as per Chemical analysis report of CPCB. The quantity of generation of this slag is around 140 million tones as FICCI said as per year from different steel industries in India.

Presently, this steel slag isn't utilised and is dumped near the costly plants. Study was carried out to utilise the slag in different layers of road construction. Technical specification of slag were developed for utilisation in the construction of embankment, sub-grade, sub-base, upper layers of road pavement.

1.1.1 Indian Roads Congress (IRC)

The central Government established the Indian Road Congress. In IRC SP.121-2018 guidance for use of iron, steel and copper slag in construction of rural roads. The selected aggregates gradation is in accordance with the Indian Road Congress (IRC) recommended gradation for a heavy-traffic-wearing course.

Scope of project

- Make use of waste product (steel slag).
- Reduce economical cost.
- Road safety aspects.
- Life span.
- Increase in strength, stability and skid resistance.
- Fatigue resistance

2. LITERATURE REVIEW

(Tuefekci M, Demirbas A. 1997): Topic: Evaluation of steel furnace slag as cement additives

Journal name: technical university of the black sea turkey

Chemical and physical properties and strength development have been studied for six granulated steel furnace slags from the normal steelmaking process. This paper reports results of research performed to develop cement mixture proportions using these slags. The influence of slag

proportions, specific surface, and water demand on compressive strength and bulk density of cement blends are presented in this paper. The different test results, which were compared with the Turkish Standards, in general, were found to be within the limits. The use of crushed sand as a fine aggregate has rapidly increased due to a shortage of river sand. Accordingly, research on crushed sand concrete is required. In this research, the fracture characteristics of crushed limestone sand concrete were experimentally investigated through a wedge splitting test, and the results were compared with those of crushed granite sand concrete and river sand concrete. The strength of crushed limestone sand concrete was also investigated. It was shown that the fracture energy of concrete was little influenced by the type of fine aggregate. In addition, the fracture energy of crushed sand concrete was slightly higher than that of river sand concrete. This seems to be due to very fine sand (VFS) included in crushed sand, which tends to improve the cohesion between cement paste and aggregate. Also, the fracture energy was not proportionally increased with an increase of concrete strength. The characteristic length of crushed limestone sand concrete was almost the same as that of river sand concrete or crushed granite sand concrete. The characteristic length greatly decreased as the strength of concrete increased.

(Ibrahim M Asi; Faisal I Shalabi. 2007) Topic: Use of steel slag aggregate in asphalt concrete mixes

Journal name: Canadian Journal of Civil Engineering

The research started by evaluating the toxicity and chemical and physical properties of the steel slag. Then 0%, 25%, 50%, 75%, and 100% of the limestone coarse aggregate in the AC mixes was replaced by SSA. The effectiveness of the SSA was judged by the improvement in indirect tensile strength, resilient modulus, rutting resistance, fatigue life, creep modulus, and stripping resistance of the AC samples. It was found that replacing up to 75% of the limestone coarse aggregate by SSA improved the mechanical properties of the AC mixes. The results also showed that the 25% replacement was the optimal replacement level.

(Mohd. Rosli Hainin. 2015). Topic: Steel slag as a road construction material.

Journal name: Jurnal Teknologi

Steel slag is a by-product obtained from steel industry. It is generated as a residue during the production of steel. Because of the high disposal cost as a waste material and the overall positive features of steel slag, it has been declared a useful construction material, not an industrial waste by most of the developed countries. Successively, it is recycled as an aggregate for the construction of roads, soil stabilization, and base and for the surfacing of flexible pavement. Despite this, a large amount of steel slag generated from steel industries is disposed of in stockpiles to date. As a result, a large area of land is being sacrificed for the disposal of this useful resource. Many researchers have investigated the use of steel slag as an aggregate in the design of asphalt concrete for the road construction.

(Liseran Padilha Thives 2015) Topic: Asphalt mixtures emission and energy consumption.

Journal name: Renewable and Sustainable energy reviews.

The construction of the main types of pavements requires energy and generates greenhouse gas emissions that impact the environment. Different types of asphalt mixtures such as cold mixtures, warm mixtures, asphalt rubber mixtures and mixtures with reclaimed asphalt pavement were assessed. The fuel used in the burners that heat and dry the aggregates is the main source of emissions. Also, the aggregates moisture content is an important parameter that influences the energy consumption.

(Faiza O. A. Khalil 2017) Topic: Experimental study of steel slag used as aggregate in asphalt mixture.

Journal name: American Journal of Construction and Building Materials

Based on intensive laboratory testing program, the characteristic properties of SSA were assessed to determine its suitability to be used in HMA. Four different percentages (0, 50, 75 and 100%) of SSA were used, and the proposed mix designs for HMA were conducted in accordance with Marshall mix design. The experiments results revealed that the mixes was replaced by SSA. The effectiveness of the SSA was judged by the improvement in indirect tensile strength, resilient modulus, rutting resistance, fatigue life, creep modulus, and stripping resistance of the AC samples. It was found that replacing up to 75% of the limestone coarse aggregate by SSA improved the mechanical properties of the AC mixes. The results also showed that the 25% replacement was the optimal replacement level.

(Martinho, F.C.G., Picado-Santos, L.G., 2020). Topic: Assessment of warm-mix asphalt concrete containing sub-products as part of aggregate blend

Journal name: International journal of pavement engineering.

The study compares warm-mix asphalt concrete (WMA) and a traditional hot mix asphalt concrete (HMA), evaluating permanent deformation, fatigue, stiffness modulus, and water sensitivity. The cost (construction only) differences are also addressed. Three WMA blends were prepared. One WMA was manufactured with the stand alone organic wax and incorporated 60% of recycled concrete aggregate (RCA). The other two used organic wax embedded in cellulosic fibers, one of them incorporated 35% of reclaimed asphalt pavement (RAP), and the other had no added sub-product.

Trial sections were constructed with plant-produced mixtures, laid and compacted with conventional equipment. When considered a global indicator representing mixtures mechanical behavior involving deformation, rutting, fatigue and moisture resistance, the results showed that performance of WMA blended with RAP and RCA was similar to HMA, and the conventional WMA was 25% better. The construction process proved to be feasible for any WMA.

(Hitesh Kumar and Sudhir Verma. 2020). Topic: A review on utilization of steel slag in hot mix asphalt

Journal name: International Journal of Pavement Research and Technology

Steel slag as aggregate has many well-known applications in road construction such as, hot mix asphalt, cement concrete mix, antiskid-layer, granular - base and subbase layers. This paper review development in various aspects of utilizing steel slag aggregate in dense graded hot mix asphalt. Properties of steel slag can significantly influence performance of roads. Chemical composition and physical and mechanical properties of steel slag have been reviewed in consideration of its suitability in asphalt mix. Findings from asphalt mix design studies indicate that, steel slag asphalt mix can be designed to satisfy both volumetric and mechanical properties.

User Guidelines for Waste and by product Materials in Pavement Construction

Guidelines by: Federal Highway Administration (U S Department of Transportation)

Steel slag can be processed into a coarse or fine aggregate material for use in dense- and open-graded hot mix asphalt concrete pavements,(1,2,3) and in cold mix or surface treatment applications.(4) Proper processing of steel slag and special quality-control procedures are extremely important in selecting steel slag for use in asphalt paving mixes. Of particular importance is the potential for expansion because of free lime or magnesia in the slag, which could result in pavement cracking if ignored. Steel slag use in paving mixes should be limited to replacement of either the fine or coarse aggregate fraction, but not both, because hot mix asphalt containing 100 percent steel slag is susceptible to high void space and bulking problems due to the angular shape of steel slag aggregate. Mixes with high void space (100 percent steel slag aggregate mixes) are susceptible to over-asphalting during production and subsequent flushing due to in-service traffic compaction.

3. CONCLUSIONS

Based on the literature, the following conclusions were drawn:

- Steel Slag (GGBS), one of the base materials results in early initial strength.
- Steel slag when use of bituminous mix improves strength and stiffness modulus and prevent the failure of the pavement.
- Pavement thickness can be reduced without compromising stability and skid resistance.
- Have no noticeable effect upon shelf life

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