Utilization of Industrial Wastes in Road Construction: A Review

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Abstract: Now a day's disposal of different wastes, mainly industrial wastes is a major problem. Since these wastes are non-biodegradable and very fine in particle size results to various environmental threats. As the number of industries and factories are rising drastically, there is a need to know the benefits of waste materials which can be recycled and reused in any other forms. The most suitable method of utilization of these industry waste materials is adopting them in construction. In many of the research works it is proved that the waste materials produced by industries can be utilized in road pavements. Large quantity of wastes is produced in these establishments. The pollution and disposal of waste material can be partly reduced by using in construction. Many Researchers have developed the specifications of road construction using industrial wastes which in turn can be possible to return higher economics [1]. The pollution and disposal problems can be minimized by utilizing these materials in road constructions. These days coarse and fine aggregates are replaced partially with industrial waste materials. Taking into considerations that natural materials are getting exhausted in nature and quantity is decreasing gradually also the extraction of good quality materials are very economic, scientists are looking forward for the improvement and utilization of industrial waste materials in road construction. A review on some of the most suitable methods are discussed in this paper. [2].

Index Terms: **Environmental Pollution, Industry Waste Materials, Road pavements, Extraction of materials.**

1. Introduction

Indian Department of Transportation (INDOT) briefly summaries the use of Industrial waste materials in road construction. It also gives an idea about the quantity of waste materials that has to be used in mix design for the construction for the effective results. Abundant growth of industrial production creates a huge volume of waste materials. Research works are continuing to ensure the alternative source of material supply to offset the increase cost of natural materials, waste disposal and energy. The main objective of this study is to search for additional waste products which are feasible for use in road construction technically, economically and eco-friendly [3]. The usage of these materials doesn't compromises the quality and performance of the highway infrastructure and not to create any damages to environmental pollutions. The main reasons of the increment of wastes are growth of population, urbanization and industrialization [4]. The necessary specifications are required to maximize the use of industrial waste in different layers in road construction. The two benefits are: (a) Help to clear valuable and huge dumps of wastes and (b) Help to preserve the natural reserves of aggregates. Therefore, proper utilization of waste materials depends on its use how these materials are being economical competitive with that of the currently used natural materials, including the cost of processing and transportation. [1]. Different types of Industrial waste in both road sub grade and sub-base are Fly ash, Cement kiln dust (CKD), Phosphogypsum, Red mud, copper slag, Marble slurry, foundry sand, rice husk ash, plastic waste, glass wastes, steel slag, blast furnace sludge etc.

2. Types of Industrial Wastes and its applications

2.1 Fly Ash

Fly ash is the finely divided residue that results from the combustion of pulverized coal and is transported from the combustion chamber by exhaust gases. In coal fired electric and steam generating plants the fly ash is produced. Fly ash is suitable for wide range of applications because of its features like excellent and multifarious properties. The cement, concrete, bricks, pavers etc are the construction materials that include the content of fly ash. Fly ash as a finally divided mineral residue of burning of coal exhibits the excellent geotechnical and pozzolanic properties and so it is suitable road constructions. In rural sectors the fly ash and fly ash based products established, they have the properties like durable, ecofriendly and economic. On large scale these products are technologies were implemented it helps to ecofriendly and sustainable constructions and new business opportunities of

employments [5]. The advantages of fly ash are: ultimate strength is high, improved workability, decrease bleeding, heat of hydration decreases, low permeability, low cost, increase durability, decreases shrinkage [1]. The geotechnical properties of fly ash soil mixtures like compaction, unconfined compressive strength, permeability are in satisfactory limits. Tremendous research work was progressed on utilization of fly ash in the various construction works including road sub bases and subgrades. The important parameter of fly ash soil mixture is its unit weight, since it controls the strength, permeability and compressibility. The engineering properties are improved by the densification of ash [6].

2.2 Plastic Wastes

The abundant production and usage of plastic is leading the environmental pollution. It does not allow water and oxygen pass through it. The plastics are durable, light, transparent and insulated. The polyethylene and polypropylene are used. An implementation of improvement of the properties of asphalt mixture and the effective recycle of the plastics, these two materials were combined together and form the asphalt and used for the construction of roads and the properties of the mixture are fluidity resistant, oil resistant and anti-stripping of porous asphalts are improved. It is suitable for the construction of road and it reduces the plastic wastes in the country [7]. Than asphalt, the recycled plastic roads are more environmental friendly. It is a great alternative to the conventional roads and it reduces the time, money, and effort. The plastic helps the roads to be durable, strength and mold ability.

2.3 Blast Furnace Slag

The byproduct of the steel making industry is blast furnace slag. The five raw materials that is utilize in the steel plants are air, water, fuel and power to produce steel. 2-4t of waste is generated during the steel production [8]. The combination of silicates and alumina silicates of lime are blast furnace slag. It will activate anyone lime or Portland cements. The rate of strength of development will be retard by using the mixture of blast furnace and ordinary Portland cements. It reduces the crack resistance of concrete. For the construction of road coatings, the slag is used basic filler in the asphalt concrete. The carrying capacity and durability of road and runway coatings are increased by using the blast furnace slag, it is a long acting binder, which make smooth in the solidification of materials used for the road construction [9]. The geotechnical properties of blast furnace slag is compressive strength will be increased. The use of blast furnace slag should be enhanced in cement making to reduce the cost of cement manufacturer. The studies carried out on blast furnace flue dust generated at steel plants have indicated that most of the carbon values can be recovered either by cell or column flotation techniques

2.4 Foundry Sand

Foundry sand is generated by the foundry industry and it is of huge quantity. The disposal of it becomes environmental, economic and social barrier. It is a dangerous waste. This waste is convenient as the sub base layer. It satisfies the geotechnical functions and environmental prescriptions to minimize the environmental pollution [10]. The foundry sand was used as the embankment fill material, an aggregate alternative in asphalt concrete and the aggregate to controlled low strength material [11]. In hot mix asphalt pavements, the foundry sand is used as an alternative material to fine aggregate. It shows a satisfactory performance [12]. Another possible use of foundry sand is an anti-skid material for roads covered with snow and ice. The highway embankments a flow able fills are the major applications. The increase in foundry sand lowers the workability. The conserve landfill capacity and sands are conserved by reusing the foundry sands. The Geotechnical properties determine by conducting the tests like proctor's compaction test, California bearing ratio test, unconfined compression test, liquid limit, plastic limit, shrinkage limit and plasticity index are in satisfactory limits to use this waste material in road constructions [13].

2.5 Sugarcane Straw

The sugarcane straws are made from reusable sugarcane fiber, which is not only a natural source for the material but is also biodegradable. The wastes from the sugarcane industries have been found out to be pozzolanic material. Sugarcane straw ash has a lower specific gravity compared to that of the soil. By considering the sugarcane straw as a filler in the soil voids and the decrease in MDD may also be explained. The increase in OMC with increase in sugarcane cane ash implies that more water content is needed in order to compact the soil -sugarcane straw mixture. The sugarcane straw ash can be used to improve the engineering properties of the soil but it is not a good stabilizer. The optimum % of the sugarcane straw ash by weight the soil for improvement in the strength characteristic of the soil sample is 4%. [14].

2.6 Glass Waste

Glass is made from readily-available domestic materials, such as sand, soda ash, limestone and "cullet," the industry term for furnace-ready recycled glass. The only material used in greater volumes than cullet is sand. Glass containers for food and

beverages are 100% recyclable, but not with other types of glass. Subsequently field tests with a nuclear density gauge and Clegg impact hammer were undertaken, as well as laboratory testing of field samples to assess the geotechnical performance of the trial sections. The field and laboratory test results indicated that adding crushed glass may improve the workability of the crushed waste rock base material but subsequently results in lower shear strength. The blend with 15% glass content was found to be the optimum blend, in which the material presented good workability and also had sufficiently high base strength. Higher recycled glass content (30%) resulted in borderline, though still satisfactory, performance. The research findings indicate that recycled crushed glass in blends with crushed waste rock is a potential alternative material to be used in footpath bases. With an increase in limestone filler material ratio there is a decrease in stability. Maximum stability is obtained at 5% filler content. The specific gravity and air voids filled with bitumen values are not affected by the change in mineral filler ratio. With the increase in limestone filler ratio the air voids decreases. Cullet glass dust material, The stability increases with the increase in filler and then the stability decreases with the increase in filler. Air void ratios are smaller. The maximum specific gravity was obtained for 9% cullet glass dust. Domestic glass waste dust: the stability increases with the increase in filler ratio. Max SG was obtained for 9% domestic glass. Therefore, cullet glass and domestic glass waste can be used in asphalt concrete mix as mineral filler material according to the Marshall method, the use of the glass waste in hot mix asphalt pavements would be very useful in view of waste management [15].

2.7 Copper Slag

Copper slag is a by-product of copper extraction by smelting. During this process, all the impurities become slag which floats on the molten metal. Ground granulated slag is often used in concrete in combination with Portland cement as a part of blended cement. Ground granulated slag reacts with water to produce cementitious properties. The produced slag which is quenched in water produces angular granules which are disposed as wastes. Copper slag is not a eco-friendly material. The use of copper slag aggregates in hot mix asphalt pavements improves the stability. It rather acts as a conventional coarse and fine aggregate for hot mix asphalt pavement [16].

2.8 Cement Kiln Dust

Cement Kiln Dust is a fine powdery material, portions of which contain some reactive calcium oxide depending on the location within the dust collected system, the type of operation, the dust collection facility and the type of fuel used. Cement is produced by burning mixtures of lime stone, minerals and other additives at high temperatures in a special rotary kiln. Hot air mixing with the raw materials creates a chemical reaction and produces Clinker, marble-sized pellets and sand-sized particles. Cement kiln dust has a similar chemical composition as cement and it has cementitious properties. Its alkalinity and particle size provides variety of beneficial options. Cement kiln dust helps to improve the properties of soil in-situ acts as an activator in pozzolanic stabilized base mixture [3]. The adsorptive capacity and cementitious properties allow reducing the moisture content and increases the bearing capacity of the soil. Main advantage of using cement kiln dust is it improves soil strength and at the same time it reduces cost and time. It can be even mixed with soil to modify the plastic limits or moisture content to provide desirable stabilized properties. Typically, the maximum particle size of cement kiln dust is about 0.3mm [17].

2.9 Phosphogypsum

Phosphogypsum refers to the gypsum formed as a by-product of processing phosphate ore into fertilizer with sulphuric acid. It is a radioactive due to the presence of naturally occurring Uranium and radium in the phosphate ore. There are approximately five tons of Phosphogypsum produced for every ton of phosphoric acid produced. Phosphate production generates large amount of wastes. The specific gravity of Phosphogypsum ranges from 2.3 to2.6. Bulk density ranges from 1470 to 1670kg/m^3 based on standard proctor compaction [18]. Presently alternative uses of waste-Phosphogypsum are considered in several countries as it has long-term storage capacity and better maintenance, presents economics as well as environmental concerns.

2.10 Red Mud

Red mud or red sludge is a high alkaline waste product that is generated in the production of alumina from bauxite in the Bayer process. Everything that doesn't get dissolved in the process is called red mud, its rusty color deriving from the iron compounds. Depending on the origin, quality and composition of the bauxite, the amount of red mud left over from the alumina refining can vary widely. Depending on the raw material processed, 1 to 2.5 tons of red mud is generated per ton of alumina produced. Disposal of red mud is typically problematic. Untreated red mud has high pH (approximately 11-13) which affects the survival of plants and this also effects environment drastically. For removal of toxic, heavy metals and metallic ions, red mud can be utilized [18]. Red mud waste is used in the construction of sub bases with the stabilizers like lime and flyash. The gypsum is also used to impart the strength in the red mud.

2.11 Marble Slurry

Marble slurry is a suspension of marble fines in water, which is generated during processing and polishing of marble. Indiscriminate disposal of marble slurry dust causes drainage problems/blocks, flow regime, air pollution and damage of agricultural land.[19].Many research works were carried out to ensure that the marble slurry dust can be utilized in road pavement layers, concrete works as well as in embankments. By using marble slurry dust in road construction it saves the soil properties and protects environment.

2.12. Rice Husk Ash

Rice hulls or rice husks are the hard protecting coverings of grains of rice. In addition to protecting rice during growing season, it can be used as building material, fertilizer etc. Rice husk ash contains Amorphous silica. Husk generated during milling is mostly used as a fuel in the paddy boilers. About 20 million tons of RHA is produced annually. This material causes environment threat, when this material is dumped it causes damage to the land and surrounding area. Recent research on Pozzolanic activity found that Rice husk ash is a potential material which can be utilized for the improvement of soil [20]. Rice husk ash is mixed even with the cement to fill the voids and to increase the strength and density

3. Conclusions

The utilization of different types of industrial wastes in road construction is reviewed by knowing its physical, mechanical and durability properties of each one of it. The use of the innovative technology helps to strengthen the road construction and also increases the road life. An evaluation based on technical, environmental and economic factors shows fly ash, blast furnaces slag, foundry sand and plastic wastes have a significant potential to replace the conventional materials for the different applications in road construction. . Few studies have been done concerning the strength, durability, stability, environment aspects for using the industrial wastes appropriately and carefully.

4. References

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