

## A REVIEW PAPER ON EFFECTIVENESS OF INDUSTRIAL WASTES IN ROAD CONSTRUCTION

Himanshu<sup>1</sup>, Shivani<sup>2</sup>, Sahil<sup>3</sup>

<sup>1,2</sup>M. Tech Scholar, Sat Priya Group Of Institutions, Rohtak, India

<sup>3</sup>Assistant Professor, Sat Priya Group Of Institutions, Rohtak, India

### 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. 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.

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

### 1. INTRODUCTION

The Indian Department of Transportation (INDOT) provides a concise synopsis of the use of industrial waste materials in the building of roads. In addition to this, it provides an estimate of the amount of waste materials that must be included into the mix design of the building project in order to achieve the desired outcomes. The exponential rise of industrial output results in the generation of a substantial amount of waste materials. Research efforts are still ongoing in order to guarantee the availability of alternate sources of material supply in order to compensate for the rise in the cost of natural resources, waste management, and energy. The primary purpose of this research is to look for more waste products that might potentially be used in road building in a manner that is sustainable from an environmental, economic, and technical standpoint. [3]. The use of these materials does not result in any degradation of the quality or functionality of the highway infrastructure, nor does it contribute in any manner to the production of environmental pollutions. Population expansion, increased urbanization, and increased industrialisation are the primary contributors to the accumulation of trash [4]. In order to get the most out of the usage of industrial waste in the various levels of road building, the proper criteria are needed. The two advantages are as follows: (a) aid in the clearing of precious and enormous garbage dumps; and (b) aid in the preservation of natural reserves of aggregates.

### 2. LITERATURE REVIEW

**K. Aravind & Animesh Das et al. (2010),**

Department of Civil Engineering, IIT Kanpur In this research the traditionally soil, stone aggregates, sand, bitumen, cement etc are used for road construction. Researcher found that optimum materials can be suitably utilized in highway construction and associated problem of pollution and disposal had partly reduced. Natural materials have a limit. In nature, its quantity is declining gradually. Also, cost of these extracted good quality of natural material is increasing.

**Mamta Mishra, (2012),**

Department of Civil Engineering, K.N.I.T, Sultanpur Researcher also observed that Blast furnace slag can be used in soil stabilization due to its hardening property when exposed to moisture furnace slag provides a great potential effective use of this waste material and produces alternate binder to cement. Coal fly ash Light weight, can be used as binder in base course in stabilization to pozzolanic property, Fly ash is an effective agent for chemical or mechanical stabilization of soils and Recycling and reuse of the waste materials are found to be an appropriate solution to the problems of dumping hundreds of thousand tons of waste on natural soil, which will result in consumptions in natural materials required for all construction activities

**Chunhua , Sihm et al. (2014)**

(Ph.D.) Department of civil engineering, MNIT, Allahabad **2014**. Researches concentrated on waste materials as replacements for highway aggregates and were summarized by two comprehensive Synthesis studies. The first NCHRP synthesis study conducted by the University of Illinois in 1972, explored the possibility of producing synthetic aggregates, benefit of re-using unsuitable materials, and use of manufactured and waste materials as supplements and replacements for conventional aggregates in highway construction. As a result, this study led to three kinds of research projects: characterization of acceptable aggregates, application of plastics to improve aggregates, and identification and cataloging of raw materials for use in the manufacturing of synthetic aggregates.

**Shiva Prasad, K. Divya Krishnan and P. R. Kannan Rajkumar et al. 2016**

Department of Civil Engineering, SRM University, Kattankulathur Crumb rubber powder mixed with both the soil showed improvement in CBR value with its addition up to 10% and there onwards decreased with further increase in crumb rubber powder. The permeability value shows a rapid increases with the increase in crumb rubber content for the both the soils. The use of crumb rubber as a stabilizer introduces a low cost method for stabilization and it significantly reduces the waste tire disposal problem that currently exist.

**Imtiaz Ahmed and C. W. Lovell et al. (2017)**

Department of Civil Engineering, Purdue University, West Lafayette, Indiana(U.S.) An evaluation based on technical, environmental, and economic factors indicated that reclaimed paving materials, coal fly ash, blast furnace slag, bottom ash, boiler slag, steel slag, and rubber tires have significant potential to replace conventional materials for various applications in highway construction and should be projected for future Construction waste or debris is any kind of debris from the construction process. Different government agencies have clear definitions. For example, the United States Environmental Protection Agency EPA defines construction and demolition materials as “debris generated during the construction, renovation and demolition of buildings, roads, and bridges.” Additionally, the EPA has categorized Construction and Demolition (C&D) waste into three categories: non-dangerous, hazardous, and semi-hazardous. Of total waste in the United States, 90% comes from the demolition of structures, while waste generated during construction accounts for less than 10%. Construction waste frequently includes materials that are hazardous if disposed of in landfills. Such items include fluorescent lights, batteries, and other electrical equipment. Technical economic, and environmental problem associated with various applications of waste materials, identified under each waste material and briefly discussed must be addressed before extensive use of these waste products in highway construction.

### **3. RESEARCH OBJECTIVE**

- 1 When waste is created, options of disposal include exportation to a landfill, incineration, direct site reuse through integration into construction or as fill dirt, and recycling for a new use if applicable.
- 2 In dealing with construction and demolition waste products, it is often hard to recycle and repurpose because of the cost of processing. Businesses recycling materials must compete with often the low cost of landfills and new construction commodities.
- 3 Data provided by 24 states reported that solid waste from construction and demolition (C&D) accounts for 23% of total waste in the U.S.[5] This is almost a quarter of the total solid waste produced by the United States.
- 4 During construction a lot of this waste spends in a landfill leaching toxic chemicals into the surrounding environment. Results of a recent questionnaire demonstrate that although 95.71% of construction projects indicate that construction waste is problematic, only 57.14% of those companies collect any relevant data

### **4. TYPES OF INDUSTRIAL WASTES AND ITS APPLICATIONS**

#### **Fly Ash-**

The burning of pulverized coal produces fly ash, which is the finely split residue that is carried out of the chamber of combustion by the exhaust gases. Fly ash may be hazardous to human health. Fly ash is created in power and steam producing facilities that use coal as their primary fuel source. Due to the outstanding and varied qualities that it has, fly ash is suited for a vast array of different uses. Construction products such as cement, concrete, bricks, pavers, and so on all have some amount of fly ash in their composition. Fly ash, which is the mineral residue that is left over after coal is burned, has exceptional geotechnical and pozzolanic qualities, and as a result, it is suited for use in road constructions. In rural areas, fly ash and goods based on fly ash have become established; these products have qualities such as being long-lasting, beneficial to the environment, and cost-effective. When used on a broad scale, these items and technologies were put into effect, which contributed to the development of environmentally friendly and sustainable buildings as well as new commercial and job prospects [5]. The benefits of fly ash include a high ultimate

strength, enhanced workability, a reduction in bleeding, a drop in heat of hydration, low permeability, a cheap cost, increased durability, and a decrease in shrinking [1]. Compaction, unconfined compressive strength, and permeability are all within acceptable ranges in fly ash soil mixes, demonstrating that their geotechnical qualities are well within acceptable bounds. The application of fly ash in different construction activities, such as road sub bases and subgrades, has been the subject of a significant amount of study that has seen significant advancement. The unit weight of the fly ash soil mixture is the most significant characteristic to consider since it determines the combination's strength, permeability, and compressibility. The densification of ash results in an improvement of the material's technical characteristics.

#### **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.

#### **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

#### **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. 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 .

#### **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%.

#### **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 decrease. 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.

### **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 an 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.

### **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 collection 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. The adsorptive capacity and cementitious properties allow reducing the moisture content and increase 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.

### **Phosphogypsum**

Phosphogypsum refers to the gypsum formed as a by-product of processing phosphate ore into fertilizer with sulphuric acid. It is 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 to 2.6. Bulk density ranges from 1470 to 1670 kg/m<sup>3</sup> 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.

## **5. 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 furnace 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.

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