Utilization of Industrial Wastes in Road Construction

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Abstract

Presently in India, about 960 million tones of solid waste is being generated annually as by-products during industrial, mining, municipal, agricultural and other processes. Advances in solid waste management resulted in alternative construction materials as a substitute to traditional materials like bricks, blocks, tiles, aggregates, ceramics, cement, lime, soil, timber and paint. To safeguard the environment, efforts are being made for recycling different wastes and utilize them in value added applications. In this paper, present status on generation and utilization of both non-hazardous and hazardous solid wastes. Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose environmental pollution in the nearby locality because many of them are non-biodegradable. In recent years, Applications of industrial wastes have been considered in road construction with great interest in many industrialized and Developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. India has a large network of industries located in different parts of the country and many more are planned for the near future. Several million metric tons industrial wastes are produced in these establishments. If these materials can be Suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. A review of various Industrial wastes for use in the construction of highway has been discussed in this paper. The waste materials are fly ash, blast furnace slag, cement kiln dust phosphogypsum, waste plastic bags, foundry sand and colliery sand, which are the industrial wastes posing problems in the disposal and being deposited near the industries in India.

Introduction

Traditionally materials like clay, sand, stone, gravels, cement, brick, block, tiles, distemper, paint, timber and steel are being used as major building components in construction sector. All these materials have been produced from the existing natural resources and will have intrinsic distinctiveness for damaging the environment due to their continuous exploitation. Nevertheless, during the process of manufacturing various building materials, especially decomposition of calcium carbonate, lime and cement manufacturing, high concentration of carbon monoxide, oxides of sulphuroxides of nitrogen and suspended particulate matter are invariably emitted to the atmosphere. In view of the importance of saving of energy and conservation of resources, efficient recycling of all these solid wastes is now a global concern requiring extensive R&D work towards exploring newer applications and maximizing us of existing technologies for a sustainable and environmentally sound management. Wastes seem to be a by-product of growth Therefore efforts are to be made for controlling pollution arising out of the disposal of wastes by conversion of these unwanted wastes into utilizable raw material. The major generators of industrial solid wastes are the thermal power plants producing fly ash, paper industries wastes etc our objective is to discuss various issues and challenges regarding disposal of industrial wastes including health issues, Inorganic solid wastes are of both non-hazardous and hazardous in nature. Inorganic non-hazardous solid wastes are primarily from mining sector and these waste the primary process rejects which constitute overburden wastes. However, the inorganic hazardous wastes are mainly from the secondary process of non-ferrous metal extraction like lead, zinc, and copper. The details of both non-hazardous and hazardous inorganic wastes generation, recycling potentials and their environmental Concerns discussed in this paper. Now-a-days disposal of different wastes produced from different Industries is a great problem. These materials pose Environmental pollution in the nearby locality because many of them are non-biodegradable. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. The lack of traditional road materials and the protection of the environment make it imperative to investigate the possible use of these materials carefully. India has a large network of industries located in different parts of the country and many more are planned for the near future. Several million metric tons industrial wastes are produced in these establishments.

Traditionally soil, stone aggregates, sand, bitumen, cement etc. are used for road construction. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for highway construction, and industrial wastes product is one such category. If these materials can be suitably utilized in highway construction, the pollution and disposal problems may be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement. Post construction pavement performance studies are to be done for these waste materials for construction of low volume roads with two-fold benefits: (a) it will help clear valuable land of huge dumps of wastes; (b) it will also help to preserve the natural reserves of aggregates, thus protecting the environment. In the absence of other outlets, these solid wastes have occupied several acres of land around plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road making, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low volume roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement.

Industrial Wastes Used in Civil Works

Utilisation of waste plastic in bituminous mixes for road construction: Bitumen is a useful binder for road construction. As the plastic materials has become part of daily life, if it is not recycled will have certain environmental impacts. Different grades of bitumen like 30/40, 60/70 and 80/ 100 are available on the basis of their penetration values. The steady increase in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature demand improved road characteristics. Any improvement in the property of the binder is the needed .Today the availability of the waste plastics is enormous, as the plastic materials have become part and parcel of daily life. They either get mixed with Municipal Solid Waste and/or thrown over land area. If not recycled, their present disposal is either by land filling or by incineration. Both the processes have certain impact on the environment .Under this circumstance, an alternate use for the waste plastics is also the needed. Thinner polythene carry bags are most abundantly disposed of wastes, which do not attract the attending rag pickers for collection for onward recycling, for lesser value. Again, these polythene/polypropylene bags are easily compatible with Bitumen at specified conditions. The waste polymer bitumen blend can be prepared and a study of the properties can throw more light on their use for road laying.

Waste plastics – as binder and modifier: Waste plastics (polythene carry bags, etc.) on heating soften at around 130°C. thermo gravimetric analysis has shown that there is no gas evolution in the temperature range of 130-180°C. Moreover the softened plastics have a binding property. Hence, the molten plastics materials can be used as a binder and/or they can be mixed with binder like bitumen to enhance their binding property. This may be a good modifier for the bitumen, used for road construction.

Fly ash used – as concrete pebbles and aggregates: 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. Fly ash is produced by coal-fired electric and steam generating plants. Typically, coal is pulverized and blown with air into the boiler's combustion chamber where it immediately ignites, generating heat and producing a molten mineral residue. Boiler tubes extract heat from the boiler, cooling the flue gas and causing the molten mineral residue to harden and form ash. Coarse ash particles, referred to as bottom ash or slag, fall to the bottom of the combustion chamber, while the lighter fine ash particles, termed fly ash, remain suspended in the flue gas. Prior to exhausting the flue gas, fly ash is removed by particulate emission control devices, such as electrostatic precipitators or filter fabric bag houses. Fly ash is most commonly used as a pozzolana in Portland cement concrete applications. Pozzolanas are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperatures to produce cementations compounds. The unique spherical shape and particle size distribution of fly ash make it good mineral filler in hot mix asphalt (HMA) applications and improves the fluidity of flow able fill and grout. The consistency and abundance of fly ash in many areas present unique opportunities for use in structural fills and other highway applications. There are three types of fly ashes, namely, fly ash, bottom ash and pond ash. Fly ash and bottom ash when transported and disposed to the pond it is termed as pond ash.

Use of fly ash in Portland cement concrete for applications in highway construction: Fly ash is used in concrete admixtures to enhance the performance of concrete roads and bridges. Portland cement contains about 65 percent lime. Some of this lime becomes free and available during the hydration process. When fly ash is present with free lime, it reacts chemically to form additional cementations materials, improving many of the properties of the concrete. There are many advantages of incorporating fly ash into a Portland cement concrete which have been demonstrated through extensive research and countless highway and bridge construction projects. Benefits to concrete vary depending on the type of fly ash, proportion used, other mix ingredients, mixing procedure, field conditions and placement.
Some of the advantages of fly ash in concrete are mentioned below:

- Higher ultimate strength.
- Improved workability.
- Reduced bleeding.
- Reduced heat of hydration.
- Reduced permeability.
- Increased resistance to sulphate attack.
- increased resistance to alkali-silica reactivity.

Use of fly ash in stabilized base course for applications in highway construction: Fly ash and lime can be combined with aggregate to produce a quality stabilized base course. These road bases are referred to as pozzolanic-stabilized mixtures (PSMs). Typical fly ash contents may vary from 12 to 14 percent with corresponding lime contents of 3 to 5 percent. Portland cement may also be used in lieu of lime to increase early age strengths. The resulting material is produced, placed, and looks like cement stabilized aggregate base. Pozzolanic stabilized mixture bases have advantages over other base materials which are shown below:

- Use of locally available materials.
- Provides a strong, durable mixture.
- Increased energy efficiency.
- Suitable for using recycled base materials.

Use of fly ash in soil improvement for applications in highway
Construction: Fly ash is an effective agent for chemical and/or mechanical stabilization of soils. The properties of soil which can be change by using of fly ash are density, water content, plasticity, strength and compressibility performance of soils, hydraulic conductivity, and so on. Typical applications include: soil stabilization, soil drying, and control of shrink-swell.

Use of fly ash in asphalt pavements for applications in highway construction: Fly ash can be used as mineral filler in hot mixed asphalt (HMA) paving applications. Mineral fillers increase the stiffness of the asphalt mortar matrix, improving the resistance of pavements, and the durability of the mix. Fly ash will typically meet mineral filler specifications for gradation, organic impurities, and plasticity.
The advantages of fly ash which are mentioned in the following:

- Reduced potential for asphalt stripping due to hydrophobic properties of fly ash.
- Lime in some fly ashes may also reduce stripping and
- May afford a lower cost than other mineral fillers.

Conclusions

A review of various Industrial wastes for use in the construction of highway has been discussed in this paper. The waste materials are fly ash, blast furnace slag, cement kiln dust and phosphogypsum which are the industrial wastes. The following are the conclusions made from the above study:

1. Fly ash can be used in concrete admixtures to enhance the performance of concrete roads and bridges.
2. Incorporating fly ash into a Portland cement concrete vary depending on the type of fly ash, proportion used, other mix ingredients, mixing procedure, field conditions and placement.
3. Fly ash and lime can be combined with aggregate to produce a quality stabilized base course. Portland cement may also be used in lieu of lime to increase early age strengths.
4. Fly ash is an effective agent for chemical and/or mechanical stabilization of soils.
5. By improving sub grade conditions by using fly ash, promotes cost savings through reduction in the required pavement thickness.

References

1. A team consisting of Washington State University, University of Wisconsin at Madison, and Bloom Compantumiies (2008). "High-Volume Use of High-Carbon Fly Ash for Highway Construction- A Case Study." Sponsored by the U.S. Department of Energy (DOE) and in cooperation with the Minnesota Department of Transportation.
2. American Coal Ash Association (ACAA). 2003a. Fly ash facts for engineers. 4th EditionHWA-1F-03-019.
3. American Coal Ash Association (ACAA). 2003b. Coal ash: Its origins, disposal, use, and potential health issues. http://www.acaa-usa.org/. September 17, 2003
4. Bhatty, Jawed. 1995. Alternative uses of cement kiln dusts. Portland Cement Association Research and Development Information.
5. Coal Fly Ash in Pozzolanic Stabilized Mixtures for Flexible Pavement Systems (Flexible Pavement Manual), American Coal Ash Association, Washington, DC.
6. Ministry of Road Traffic and Highway Manual for construction and supervision of Bituminous works, Mc Delhi .November 2001.
7. Sri Ram Institute for industrial Research, plastic Processing and Environmental Aspects, New Delhi 7.