USAGE OF INDUSTRIAL WASTE PRODUCT FOR VILLAGE ROAD AND HIGHWAY CONSTRUCTION

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Abstract:-Now-a-day's 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 in many Industrialized and developing countries. The use of these materials in road making is based on technical, economic, and ecological criteria. 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 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 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.

Keywords: Industrial waste, Fly Ash, Blast furnace slag, Cement kiln dust, Phosphogypsum, Waste plastic bags, Foundry sand and colliery sand.

I. INTRODUCTION

The Road and Highway are considered as connector between two places and a medium for vehicle to run. Both contribute towards the development of country. If anything happens to them it directly affect vehicle as well as human being that's why roads and highways must be strong, smooth and properly constructed with suitable materials. In different part of world different technique are use for making roads and highways depending upon what kind of material is available, cost, location and many other factor. In India most of the roads are constructed by mixture of aggregate, concrete, cement and bitumen also know as asphalt a black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation used for road surfacing and roofing. After funding much of the amount and natural resources condition of roads as well as highways is very critical mostly in villages causing number of problems such formation of potholes, soil erosion due to water, soil particles loose surface and many more which can cause accidents so better way is to finding out alternate solution or using different methods to overcome this problem.

Fig. Village side damaged road

Now-a-days disposal of different wastes produced from different Industries is a great problem. This is not good for human beings as well as environment. As we all know that Industry, construction and other comparable activities produce large quantities of by-products and recycled materials, which are potentially suitable for earth construction.[5] Over many million tones of natural mineral aggregate are used each year for earth and road construction which not only higher the cost but also responsible in reduction of natural resources.[3] Urbanization and Industrialization have resulted in a serious depletion of high quality construction materials in developed areas, but they have resulted in large accumulations of waste materials and industrial residues. Typical examples of these are mine waste rock and slimes, domestic refuse, slags and ashes and industrial by-products such as phosphogypsum from the fertilizer industry.[2] As there is a rapid growth in population drastic reduction in natural resources can be found which can pressurize the industries to increase their production rate due to which more waste materials is generated can be dumped result in valuable areas so there is need to clear the valuable areas and to get the alternate solution for industrial waste. The alternate solution for industrial waste is to use it for construction of Roads and Highways and also the problem of having smooth and better road and highway can be solved. This is done by using suitable waste for construction by

proper study and analysis. We can either add the material to concrete mixture or by varying concrete mixture. This will help not only in lowering the cost but also conserve the natural resource. Today the most common problem that the world facing is waste plastic which can be use or mix with bitumen for construction of roads that provides strength and smoothness to them. By doing this we can say that we can protecting our environment and ecosystem to some extent.[8]

II. LITERATURE REVIEW

Many people carried out different experiments and useful works on different industrial waste so that we can use them in road and highway construction rather than dispose in environment.

In 2008, Robert Patton et al; did the study to find solution to high volume high carbon fly ash utilization. As we know that combustion of coal produces large volume of byproducts, including fly ash, flue gas desulfurization (FGD), and bottom ash, etc. He worked with the U.S. department of Energy that sponsored this study to build test sections at MnROAD. Three test sections were built at MnROAD test road which is divided into 3 different test sections with same asphalt layers, subbase, and sub grade, but three different base courses materials: conventional crushed aggregates, full depth reclaimed pavement materials (RPM), and CHCFA stabilized RPM materials. A single heavily loaded truck continuously drives on the sections with some sensor, to sense various properties, even on heavy rain and after it they conclude that road with RPM base is remain unaffected even in heavy rain while other two wet base materials were never dried up and eventually had to be removed.[1]

In 2000, Paige Green et al; did study on Phosphogypsum a residue result from production of phosphate fertilizers from phosphate bearing rock by reaction with sulphuric acid. In his study he mentioned that Phosphogypsum is a major by-product generated in the United States with significant production in Texas, Florida and Louisiana which can potentially useful substitute for traditional road construction materials after doing various laboratory testing of 10 samples of BPG that is By-product Phosphogypsum is collected from Chloorkop plant, field trial, construction and after 18 months of monitoring they come to the conclusion that By-product phosphogypsum (BPG) having properties significantly different from conventional natural materials which is potentially useful for road construction material and they have been shown to be cost-effective compared to conventional materials.[2]

In 2002, Mroueh et al; did study by considering the earth construction in Finland with the use of fly ash and blast-furnace slag for over 30 years. As per his study he estimated that over 50 million tones of natural mineral aggregate are used each year for earth and road construction which is an evident to substitute materials because in the most populated areas the depletion of materials, such as natural sand and gravel, has increased. The use of by-products as substitute materials also fulfills the strategic goals of current environmental legislation. He also explained various laws related to environment, Assessments such as Risk, environment compliance, extensive study on various factors affecting the acceptability of various secondary products for earth construction, technical applicability of these materials.[3]

In 1996, Tarun Naik et al; do research on how to evalute the performance of foundry by-product in concrete and masonry product. Masonry is the building of structures from individual units, which are often laid in and bound together by mortar. He carried out two experiment in that first one was use of an air cooled foundry slag in concretes a partial replacement of coarse aggregate and second one was to involved the use of foundry sand as a partial replacement of fine aggregate for making masonry blocks and paving stones. This two experiment can be carried on the basis of physical and chemical properties of cement.[4]

In 2010, Tara Sen and Umesh Mishra et al; studied the great problems related to industrial waste which pose environmental pollution in the nearby locality as some of which are non-biodegradable and according to that they study about various industrial waste such as fly ash, blast furnace slag, cement kiln dust phosphogypsum, waste plastic bags, foundry sand and colliery sand , which are posing problems in the disposal and being deposited near the industries in India on the basis of these properties, origin, various sources and how it is useful for other purpose. On this data they proposed that this industrial waste can be use in road and highway construction with great interest which is based on technical, economic, and ecological criteria. For example Use of fly ash in grouts for pavement subsealing for applications in highway construction, Use of cement kiln dust as mineral filler in asphalt paving and so on.[5]

In 2013, Aditya Kumar et al; did study on how to assess the usefulness of agricultural and industrial waste as a soil admixture, and focused to improve the engineering properties of soil to make it capable of lower layer of road construction. He worked on various agricultural wastes such as Rice Husk Ash (RHA), Bagasse Ash (BA), Fly Ash (FA), Rice Straw Ash (RSA) and soil on the basis of physical and chemical properties. He also carried out Various tests like shrinkage limit (SL), California Bearing Ratio (CBR) and Standard Proctor (SP) in which he combine soil with RHA, BA and FA.[6]

In 2017, Manju Anand et al; did study on the waste plastic and its disposal that is a major threat to the environment, which results in pollution and global warming by utilizating it in bituminous mixes by various test such as Aggregate Crushing Test, Abrasion Tests, Impact Test, Bitumen penetration Test, Marshall Stability Test and many more. These tests result in reduction of crushing value from 23.32 to 14.22 for normal and plastic coated aggregate. The value was reduced by 40%. Lower the aggregate crushing value higher is the strength. The aggregate impact value of plastic coated aggregate was reduced by 9% than the normal aggregate. It's the higher toughness of plastic coated aggregates. After doing all this he finally come to the conclusion that the plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This results in the reduction of ruts and there is no pothole formation. The plastic

pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 10% and increases the strength and performance of the road. This new technology is eco-friendly.[7]

III. TYPES OF ROAD

1. Earth road :

This technique is most popular in semi-rural and rural areas. The raw material used is earth like the name suggests. It does not require much skill for it to be put into place. All you need is the right machinery i.e. excavators and rollers.

2. Gravel Road:

This is an advancement of the earth road. It is common in semi-rural, semi urban and rural areas. Here you use the same process as the earth road but you add a layer of gravel after the earth is compacted.

3. Bituminous Road:

Bitumen is the key material in this method. This method is the most preferred due to its flexibility. It made of four layers of bitumen. The bottom layer is the thickest and the subsequent three layers keep on thinning as the get to the top. Now a day's plastic is also added into bituminous mixture for long life of the road.

4. Water Bound Macadam:

This method involves interlocked broken aggregates that are bound with water and filler material where the base course is well compacted. Aggregates impart enough strength thus no void is left behind. It is cheaper compared to the bituminous option.

5. Concrete Road:

This method uses a mixture of Portland cement and asphalt. They are most common in urban areas. The edges are made thicker than the middle part. Concrete roads are made to handle heavy traffic flow. This is an all weather road. It built to last up to ten years as it has lower maintenance issues.

6. Kankar Roads:

Kankar is nothing but impure form of lime stone. Kankar roads are provided where lime is available in good quantity. These are also low quality and performance wise they are similar to gravel and murrum roads.

7. Murrum Roads

Murrum is a matter obtained from the disintegration of igneous rocks by weathering agencies. This is used to make roads called as murrum roads.

IV. PROCEDURE

1. Generally, the road are constructed considering the geographic structure, use of materials that are far more improved and durable.
2. Rock and earth material is removed by explosion or digging and then Embankments, tunnels, and bridges are constructed.
3. One of the major works involved in road construction is earthwork which includes excavation, material removal, filling, and compaction.
4. Compaction is done based on standard design procedures and filling is done to reach the road level and the fill layer is distributed and compacted to the designed specifications.
5. The filling is of concrete which is a mixture of water, aggregate (rock, sand, or gravel) and cement.
6. This procedure is repeated until the compaction desired is reached which is carried out using bulldozer. Bulldozer is also useful to throw the waste excavated material on the road sides and proper sloping of the roads.
7. This is how the roads are constructed.

V. EXPERIMENTAL STUDY

In Otsego, United State the study is going on the contruction of roads which uses different technique and industrial waste materials of construction purpose. The study is conducted by U.S. department of Energy which build test sections at MnROAD accelerated testing facility, with the cooperation of the Minnesota Department of Transportation (MDOT).

To study the performance evaluation, three test sections were built which represent varying combinations of road building asphalt layers, subbase, and subgrade, but different base courses materials. A single heavily loaded truck continuously drives on the sections and this could provide direct comparison of the performance between the sections. MnROAD is equipped with a great number of sensors in the pavement to detect traffic volume, stress and strain under loading, moisture, and temperature. HMA performance test is also carried out to relate the lab test material or actual material. In this way they carried out different test and make the report on that, which is submitted to department of transportation they evaluate and give their decision.[1]

VI. ALTERNATE ROAD CONSTRUCTION MATERIALS

As discussed above that why various industrial wastes rather than dispose can be use in road and highway construction. Waste that dispose can be classified into five types which is all commonly found around the house. These include liquid waste, solid rubbish, organic waste, recyclable rubbish and hazardous waste. Some of the common industrial waste that can be use for construction are as follow

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. The unique spherical shape and particle size distribution of fly ash make it good mineral filler in hot mix asphalt (HMA).

Fly ash is used in concrete admixtures

a. It enhance performance of concrete by chemically react with lime in cement to form additional cementitious materials, improving many of the properties of the concrete.
b. To produce a quality stabilized base course which is referred as pozzolanic-stabilized mixtures (PSMs) have many advantages over other base materials.
c. to produce grouts which is again use to fill voids under a pavement system without raising the slabs or to raise and support concrete pavements at specified grade tolerances.[5]

2. Blast Furnace Slag

Blast furnace slag is generated during the melting process in steel making operations. The slag is a fairly complex mass that is relatively inert. It is composed of metal oxides, melted refractory, and sand from recycled scrap castings, coke ash, and other materials. Blast furnace slag has been beneficially used in a number of applications. The most significant factor that determines whether or not blast furnace slag is suitable for use is the particle size. Blast furnace slag is

a. Generally used as cementitious binder which is first developed in France under the title gravel-slag to stabilise gravel and sands for sub-base and base construction.
b. Also been used in asphalt mixtures as it is lower cost than other mineral fillers and the slag is usually crushed to achieve the desired particle size.[5]

3. Cement Kiln Dust

Cement kiln dust (CKD) is the finely divided dry alkaline particulate matter carried from a cement kiln by the exhaust gas, and captured by the kiln's air pollution control system. The composition of cement kiln dust is similar to that of cement and consists of calcium carbonate, calcite, silicate, potassium sulphate and other compounds. It also has similar chemical composition and its alkalinity and particle size also provide value for a variety of beneficial use options. Cement kiln dust is

a. Use to improve the properties of soil in situ and as an activator in pozzolanic stabilised base mixtures having adsorptive capacity and cementitious properties to reduce the moisture content and increase the bearing capacity of the soft soil.
b. Use to replace a portion of the mineral filler used in hot-mixed asphalt which is made by coating of dried coarse and fine aggregates with hot asphalt cement.[5]

4. Phosphogypsum

In fertilizer industries the Phosphate rock is processed to make phosphoric acid. In wet process the phosphate rock is treated with sulfuric acid to produce the phosphoric acid which is the finished product in the fertilizer. The by-product remaining after the acid conversion is largely calcium sulfate and has been given the name phosphogypsum. We know that phosphate production generates huge amounts of wastes. From research it is found that the production of each ton of phosphoric acid will produce 4½ tons of phosphogypsum which can be pumped to disposal sites in form of slurry from stacks. Instead of disposing the phosphogypsum slurry to sites it can be reused for highway construction aggregate as crushed base and crushed aggregate for asphalt. [5]

5. Plastic

The disposal of waste plastic is the major threat to the environment as well as human beings which results in pollution and global warming. Plastic is simply define as a material that contain one or more organic polymer of large molecular weight, solid in its finished state and can be shaped by its flow. We know that it is non-biodegradable and remain in soil for years. Instead of this waste plastic can be used for road and highway construction. Plastic waste can be

a. Utilize in bituminous mixes to enhance its properties and strength. Further, it is also be a solution to plastic disposal & various defects in pavement due to pot holes, corrugation, ruts, etc.
b. Shredded and coated over aggregate, mixed with hot bitumen and resulting mixture is used for pavement construction which not only strengthen the pavement and also increases its durability.
c. Economical and Eco-Friendly.[7]

VII.ENVIRONMENTAL SAFETY

As we all know that humans are exploiting the natural resources rapid and the government try to save the environment by establishing different act and policies in order to reduce the harmful effects on environment to some extent. Also, by using the industrial waste in road construction can contribute towards safety of environment and by doing this we can conserve our natural resources as well.

VIII. CONCLUSION

In order to ensure sustainable delivery of roads and highways construction there should be change in material which provides strength, stiffness, etc. Use of industrial waste in road construction is very useful as

- It increases stiffness, provide better strenght and many other properties
- Water absorption of foundry slag aggregate is much lower than light weight aggregate.[4]
- Using wastes as construction material will be cost effective compared to conventional materials and conserve the natural resources.
- Use of plastic will reduce the need of bitumen by around 10% and also improve fatique life of road and increase the melting point.[7]

Also from the literature we can conclude that the Fly Ash, Blast furnace slag, Cement kiln dust Phosphogypsum, Waste plastic bags, Foundry sand and colliery sand use in road and highway construction is very useful and cost effective which helps in conserving the natural resources which are getting depleted rapidly due to increase need of population. To maintain and even increase the delivery of the road infrastructure in line with the expected increasing demand, greater use is going to have to be made of such materials in future. A change in engineering thinking will be necessary. In future it is expected to use more and more useful industrial wastes for road and highways construction.

REFERENCE

1. A team consisting of Washington State University, University of Wisconsin at Madison, and Bloom Companies (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. Paige-Green, P. and Gerber, S. (2000). "An Evaluation of the Use of By-product Phosphogypsum as a Pavement Material for Roads." South African Transportation Conference, South Africa 17-20 July 2000.
3. Mroueh, U. M., and Wahlstrom, M. (2002). "By-Products and Recycled Materials in Earth Construction in Finland –An Assessment of Applicability."Resources, Conservation and Recycling, No. 35, 2002, pp. 117–129.
4. Naik, Tarun, Shiw Singh, Matthew Tharaniyil, and Robert Wendorf. 1994. Application offoundry by-product materials in manufacture of concrete and masonry products. Center for By-Product Utilization, University of Wisconsin-Milwaukee. CBU-1994-04.
5. Tara Sen and Umesh Mishra (2010). "Usage of Industrial Waste Products in Village Road Construction." International Journal of Environmental Science and Development, Vol. 1, No. 2, June 2010 ISSN:2010-0264.
6. Aditya Kumar Anupam, Praveen Kumar and G D Ransinchung R N (2013). "Use of Various Agricultural and Industrial Waste Materials in Road Construction." 2nd Conference of Transportation Research Group of India (2nd CTRG).
7. R.Manju; Sathya S; Sheema K (2017). Use of Plastic Waste in Bituminous Pavement. International Journal of ChemTech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555 Vol.10 No.8, pp 804-811, 2017.
8. Dr. R. Vasudevan Dept. of Chemistry, TCE, MDU (2013). "Reuse of Waste Plastics Coated Aggregates-Bitumen Mix Composite for Road Application – Green Method." ,American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-02, Issue-11, pp-01-13.
9. Sayeed Javed, Purdue University (1992) "Use of Waste Foundry Sand in Highway Construction", School Of civil Engineering, Joint Highway Research Project Interim Report JHRP-92/12.
10. Ms. Amruta Mundhe, Dr. Prof. A. W. Dhawale Professor and Hod of Civil Engineering Department, JSPM Imperial College of Engineering and Research Wagholi, Pune (2018). "An Overview of Use of Waste Plastic in Road Construction", Journal of Advances and Scholarly Researches in Allied Education Vol. XV, Issue No. 2, (Special Issue) April-2018, ISSN 2230-7540.
11. J.M. Reid. "Alternative materials in road construction." Transport Research Labroratory, Ground Engineering, UK
12. Lye` s Chaouche, Romain Trauchessec "Modulation of Alpha Coefficient (a) and Reactivity in Granulated Blast Furnace Slag Binders Used in Road Construction", Journal of Sustainable Metallurgy.
13. C.W. Lovell, Neonard D Wood. "Waste Foundry Sand In Asphalt Concrete", Transportation Research Record 1437, School of Civil Engineering, 1284 Civil Building, Purdue University, West Lafayette, Ind. 47907.
14. Azmat Shaikh, Nabeel Khan, Faisal Shah, Devendra Shukla, Gaurav Kale (2017). "Use of Plastic Waste in Road Construction", Student, Department of Civil Engineering, Dr. D.Y. Patil School of Engineering & Technology, Maharashtra, India.
15. Tuncer Edil, Craig Benson (2002). "Use of Industrial By-Products as Geo Materials", Professor Of Civil And environment at the University of Wisconsin-Madison.