Potential of Waste Material Utilization in Subgrade Construction for Sustainable Development- In Indian Context

Sanjay Kumar Shrivastava[1], Prof. (Dr.) Shalini Yadav[2], Dr. B. S. Singla[3]

[1]*PhD Research Scholar, Rabindranath Tagore University, Bhopal*

[2]*Professor of Civil Engineering in Rabindranath Tagore University, Bhopal*

[3]*CGM (Technical), NHAI, New Delhi*

Abstract- Sustainable development is the key focus of the development policy of India. There has been an increasing appreciation of the importance on sustainable development by reusing the wastes of the society. India's road infrastructure is an area that presents many opportunities for increased sustainability, by the use and re-use of materials and methods that minimize the impact of construction activities on environment. There are case studies that conclude that the waste materials which are forming environmental loads can be used in subgrade soil to replace the borrowed soil, which will helps in sustainable development, but disposal of unsuitable soils is also causing disturbances to the natural environment. Thus recycling of soil and societies waste is especially important to the countries which are lacking in natural resources. It will be an environmental friendly solution from application to end-result.

Keywords: Environment friendly, Green Solution, Soil Stabilization, Subgrade, Waste Management.

I. INTRODUCTION

Effect of climate change on environment can be differed by adopting sustainable development with singular approach of reducing the consumption of natural resources. As road infrastructure development consumes large amount of natural resources, an emphasis is much needed to be given on new and innovative construction technologies. Development to reduce wastage and reusing of waste materials can be one way for it. For sustainable development wastes are to be converted into a resource. The present model of development is based on human needs and not on sustainable development and thus has to be considered more by those in higher level of need as they consume considerable natural depleting resources. The growing demand of the sustainable development is to look in opportunities to use various blends of locally available waste materials so as the properties of subgrade soil is not varied much with optimum utilization of waste materials. The use of waste material can also enhance the properties of soil to be used as subgrade.

II. IMPORTANCE OF SUBGRADE IN ROAD CONSTRUCTION

Roadbed portion on which pavement, surfacing, base, sub-base is placed is called 'Subgrade'. Pavements are engineered (IRC 37; 2012) to distribute stresses imposed by traffic to the subgrade and the subgrade conditions have a significant influence on the choice and thickness of upper pavement structure. The main function of the subgrade is to give adequate support to the pavement and for this the subgrade should process sufficient stability under adverse climate and loading conditions. Sub base material mainly contain soil, sand, moorum, gravel, laterite, kankar, brick metal, crushed stone, crushed slag, etc.

The nearby existing soil at site, with requisite properties of the subgrade (as per MORTH specifications) provides platform for the construction of subsequent layers and also provide adequate support for the pavement over it. Much research have been conducted on the subject of poor/marginal soils and their base modification during the past several decades.

The present paper is emphasizing on "use of societies waste materials", which cannot be reused or are currently environmental burden. The use of use of society waste will be reducing loads on traditional conventional construction materials. Utilization of these waste materials is not only an economical alternative but also an eco-friendly alternative of waste management. It will reduce load and pressure from landfills and hence reduce energy consumption and green house gas emissions, and thereby technique is suitable for sustainable development.

Major environmental challenges associated with waste are, its collection, transport, treatment and disposal. Its impacts on the environment and public health are very significant, but so are the opportunities to use them as alternatives, specifically to be used in road bed portion i.e., specifically in "Subgrade". There is increasing pressure to keep all potentially reusable and recyclable materials from landfills which are taking up valuable space in the mid of urban population.

The authors have shown by their field experiments that societies waste can be used is subgrade successfully, mentioned in references.

III. LITERATURE REVIEW

Soil stabilization for road construction is now a matter of much concern in developing and developed countries. J. James and P. K. Pandian in 2016 used industrial wastes as auxiliary additives to cement & lime to stabilization of soils. They further used expansive soil amended with bagasse ash and coconut shell powder. Alemu Diribsa Gudeta, et. al. (2017), reviewed various industrial wastes as admixies and G.V. L. N. Murthy, et.al.(2017), conducted a study on partial replacement of clayey soil with an industrial effluent in 2018, E. Soyonar, et. al. used steel slag and fly ash with Soil as subbase materials. Deng-Fong Lin, et.al. in 2016, studied behavior of subgrade soil when mixed with a sewage sludge ash/cement mixture and nano-silicon dioxide, whereas Srinivasa Reddy N, et. al. (2017), used burnt municipal solid waste and Lime as admixture in local subgrade soil for stabilization.

.

Many researchers found the potential of use of agricultural waste as admix for subgrade soil. H. Hasan, et. al. (2016) used bagasse ash as admixture to Expansive Soils and A.K. Yadav, et. al. (2017), worked with agricultural wastes for soil stabilization. A. Busari, et. al. (2018), used bamboo straw ash to improve the index properties of soil for sustainable development. D. Gupta and A. Kumar (2017), conducted performance evaluation of cement-stabilized pond ash-rice husk ash clay mixture as a highway construction material.

In 2017, B. Ajmera, et. al., compared soil characteristics soils mixed with crumb-rubber tyre Mohammed Ali Mohammed Al-Bared, et. al.in 2018, utilized recycled tiles and tyres in Soils.

N. C. Consoli, et. al. (2016), emphasized on strategies for developing more sustainable dosages for soil–coal fly ash–lime blends.

Shrivastava S. K., et. al. .(2018), did experimental analysis on in-house soil to be used as sub grade with lime, cement, silt, fly ash for stabilization. They further emphasized on selection of locally available waste material to be used as admixture in subgrade for sustainable development. They also did a case study on innovative measures to reduce road construction time.

Surya Mani Kantha. A, et. al. .(2016), applied RHA and lime in black cotton soil for improving strength and swelling characteristics.

IV. PROPOSED METHODOLOGY

SELECTION OF WASTE MATERIAL

The most important part is selection of waste material which can be used as admix in subgrade soil without negatively affecting its engineering properties. This procedure considers three major aspects of waste source utilization:

1. Technical,
2. Economical, and
3. Environmental.

1. Technical: Based on Engineering Properties

The basic four desired properties of base and subgrade layers are:

a. Shear strength (the ability to resist shear stresses developed as a result of traffic loading);
b. Modulus or stiffness (the ability to respond elastically and minimize permanent deformation when subjected to traffic loading);
c. Resistance to moisture (the ability to resist the absorption of water, thus maintaining shear strength and modulus, and decreasing volumetric swell);
d. Stability (the ability to maintain its physical volume and mass when subjected to load or moisture), and
e. Durability (the ability to maintain material and engineering properties when exposed to environmental).

Suitability/Unsuitability of materials for embankment and subgrade should be in line with MORTH Specifications.

The major tests which shall be carried out for identification of subgrade properties after mixing with wastes are listed in Table-1.These results will help in selection of waste additive in optimum quantities for modified subgrade.

Sr	Engineering Tests	Analysis
1	Grain-Size Analysis	coefficient of uniformity
2	Liquid and Plastic Limits	value of PI (Plasticity Index)
3	Free Swell Index	cracking behavior of plastic soils
4	Water Content and Dry Density Relation	
A	Maximum Dry Density (MDD)	The highest density obtainable when the compaction is carried out
B	Optimum Moisture Content (OMC)	The moisture content at MDD.
5	California Bearing Ratio	The ratio of force per unit area required to penetrate a

		soil mass, the resistance of the soil to deformation by shearing
6	Unconfined Compressive Strength	The resistance to increasing loads until failure
7	Durability	The resistance of compacted stabilized soils to repeated adverse weather conditions

Table-1 Engineering Tests to be conducted for performance assessment of subgrade after mixing with waste materials

2. Economical: Based on Direct Costs

There may be many economical indicators based on which the selection of waste additive can be made. Some of the indicators which can be considered for cost benefit analysis are listed as:

a. Economic Indicators for waste
b. Cost of Transportation to the site
c. Cost of material at Source
d. Cost of Mixing at Site
e. Availability of additive
f. Cost of skilled manpower
g. Cost of specialized Machinery
h. Cost of segregation

3. Environmental: Based on Indirect costs caused by pollution

The household trash (solid waste comprising of garbage and rubbish, such as bottles, cans, clothing, compost, disposables, food packaging, glass, food scraps, old building materials, newspapers and magazines, etc) and waste disposed by various industries like thermal power plants, chemical, mechanical and agriculture industries are collected in landfills. These materials cause environmental pollution in their locality as most of them are non-biodegradable material or it takes years to decompose. Industrial wastes are hazardous in nature due to presence of toxic substances and may damage human, animal and plant resource. Some of the wastes are detailed below just for explaining its potential.

a. Fly-ash: Fly-ash (FA) is an industrial waste of thermal power plants and it is available in fine dust form. FA contains traces of toxic metals such as Cr, Th, Pb, Hg, Cd, etc. which hampers the health of humans, animals and plants growth too.
b. Rice husk: Yearly production of rice in India is about 0.32 million tons resulting huge husk production. Rice husk being agricultural waste dumped near the mills or burnt in open fields. Once it is burnt it produces rice husk ash which is equivalently harmful for humans, animals and plants, in an uncontrolled environment of village (Yadav A.K, et. al., 2017)

Some of wastes are classified in Table-2

Sr	Types of solid wastes	Source details
2	Industrial wastes (inorganic)	Coal combustion residues, steel slag, bauxite red mud andConstruction debris
3	Mining/Mineral waste	Coal washeries waste, mining overburden waste Tailing from iron, copper, zinc, gold, and aluminium industries
4	Non hazardous other process waste	Waste gypsum, lime sludge, lime stone waste, marble processing residues, broken glass and ceramics, and kiln dust
5	Hazardous Waste	Metallurgical residues, galvanising waste, and Tannery waste

Table-2 Waste Classification

The three major aspects of waste source utilization namely Technical, Economical, and Environmental are having very complex matrix and can be calculated with various mathematical models, keeping in mind that the environment management parameter is paramount.

Life cycle cost also needs to be considered while designing the road infrastructure as capital cost based design considers only initial cost without considering other important parameters like energy efficiency, environmental effect, sustainability, as it becomes difficult to quantify their long term benefits.

V. CONCLUSION

This paper presents details of how utilization of waste materials as stabilizer/modification for subgrade construction. Use of locally available waste materials in soil as admixture is definitely beneficial for the developing countries like India where economy is the prime concern for adopting any new method or technique. Additionally it provides safe disposal mechanism for the wastes, which will help in reducing the hazardous effect on the environment of the region (Jijo James and P. Kasinatha Pandian, 2016). It presents the criterion of selection of waste material to be used, without hampering the engineering properties of the road. Use of non biodegradable waste materials from urban land fill directly in embankment after segregation without blending with soil is also under study by the authors.

VI. FUTURE SCOPES

The future scope of research is identification of more and more locally available waste products which can be mixed in natural soil for laying it as subgrade. Once the waste is identified, it is important to find the time saving techniques to calculate the proportion of different wastes in different soil in a mixture. Moreover the technique of getting homogeneous mixture at site is an area of research in future.

VII. REFERENCES

[1]. Alemu Diribsa Gudeta, et. al., 2017, "A Critical review on soil stabilization using different industrial wastes and admixtures", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 04 Issue: 12.

[2]. Anjani Kumar Yadav, et. al., 2017, Stabilization of alluvial soil for subgrade using rice husk ash, sugarcane bagasse ash and cow dung ash for rural roads, International Journal of Pavement Research and Technology.

[3]. Ayobami Busari, et. al., 2018, Sustainability in Road Construction: Using Bamboo Straw Ash to Improve the Index Properties of Lateritic Soil, DOI: 10.14207/ejsd.2018.v7n1p89.

[4]. Beena Ajmera, et. al., 2017, Compaction Characteristics, Unconfined Compressive Strengths, and Coefficients of Permeability of Fine-Grained Soils Mixed with Crumb-Rubber Tire, Journal of Materials in Civil Engineering, Volume 29, Issue 9.

[5]. Deepak Gupta, Arvind Kumar, 2017, Performance evaluation of cement-stabilized pond ash-rice husk ash clay mixture as a highway construction material, Journal of Rock Mechanics and Geotechnical Engineering.

[6]. Deng-Fong Lin, et.al., 2016, Enhancing soft subgrade soil with a sewage sludge ash/cement mixture and nano-silicon dioxide, Environmental Earth Sciences, 75:619

[7]. Emre Soyonar, et. al., 2018, Performance of Steel Slag and Fly Ash Added Soil as Subbase Materials, In book: Proceedings of 3rd International Sustainable Buildings Symposium (ISBS 2017), pp.799-807.

[8]. Godavarthi V. L. N. Murthy, et.al., 2017, An Experimental Study on Partial Replacement of Clayey Soil with an Industrial Effluent: Stabilization of Soil Subgrade, GeoMEast, Soil Testing, Soil Stability and Ground Improvement pp 337-348.

[9]. Hayder Hasan, et. al., 2016, Remediation of Expansive Soils Using Agricultural Waste Bagasse Ash, Procedia Engineering.

[10]. Jijo James and P. Kasinatha Pandian, 2016, Industrial Wastes as Auxiliary Additives to Cement/Lime Stabilization of Soils, Advances in Civil Engineering.

[11]. Jijo James, P. Kasinatha Pandian, 2018, Select geotechnical properties of a lime stabilized expansive soil amended with bagasse ash and coconut shell powder, SSP – Journal of Civil Engineering Special Issue, March 2018.

[12]. Mohammed Ali Mohammed Al-Bared, Nima Latifi, Aminaton Marto, 2018, Utilization of Recycled Tiles and Tyres in Stabilization of Soils and Production of Construction Materials-A State-of-the-Art Review, KSCE Journal of Civil Engineering.

[13]. Nilo Cesar Consoli, et. al., 2016, Strategies for Developing More Sustainable Dosages for Soil–Coal Fly Ash–Lime Blends, Journal of Materials in Civil Engineering, Volume 28, Issue 11.

[14]. Shrivastava Sanjay Kumar, et. al., 2018, Performance Assessment of In-House Soil to be used as Sub grade with Lime Stabilization, Asian J. Exp. Sci., Vol. 32, No. 2, 2018; 35-38.

[15]. Shrivastava Sanjay Kumar, et. al., 2018, Selection of Locally Available Waste Material in Subgrade Construction for Sustainable Development, © 2018 JETIR August 2018, Volume 5, Issue 8, www.jetir.org (ISSN-2349-5162), pp 688-691.

[16]. Shrivastava Sanjay Kumar, et. al., 2018, Innovative Measures to Reduce Road Construction Time- A case study: Dasna Hapur Road Project, © 2018 IJEDR 2018 | Volume 6, Issue 3 | ISSN: 2321-9939, www.ijedr.org, pp 420-422.

[17]. Srinivasa Reddy N, et. al., 2017, Use of Burnt Municipal Solid Waste and Lime in Local Subgrade Soil Stabilization for its Use in Low Traffic Volume Roads, International Journal of Advanced Engineering, Management and Science.

[18]. Surya Mani Kantha. A, et. al., 2016, Application of RHA and Lime in Improving Strength Swelling Characteristics of Black Cotton Soil, International Journal of Civil and Structural Engineering Research.