Selection of Locally Available Waste Material in Subgrade Construction for Sustainable Development

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Abstract: India faces major environmental challenges associated with waste generation and inadequate waste collection, transport, treatment and disposal. Present system of waste disposal in India cannot cope with the volumes of waste generated by an increasing urban population, and its impacts on the environment and public health. The challenges and barriers are significant, but so are the opportunities to use them as alternatives, specifically to be used in subgrade. There is also increasing waste management environmental pressure to keep all potentially reusable and recyclable materials from taking up valuable space in ever-scarce landfills and pressure to reduce energy consumption and green house gas emissions. The utilization of these waste materials in subgrade will not only be an economical but will also be an eco-friendly alternative in nearby areas for road construction.

This paper presents the selection criteria of waste materials to be used as subgrade without compromising its requisite engineering properties. This would help environment management and sustainable development.

KEY WORDS: Modification of soil, Environment friendly Subgrade, Sustainable development, Waste management.

1.0 Introduction

Over the past ten years there has been an increasing appreciation of the importance of sustainability. The construction of highways is an area that presents many opportunities for increased sustainability, by the use of materials and methods that minimize the impact of these activities on the environment. There are publicly available case studies which illustrate that the waste materials can be used in subgrade soil to improve its strength in addition to help in sustainable development.

Subgrade is roadbed portion on which pavement, surfacing, base, sub-base, is placed. Flexible pavements are designed (IRC 37; 2012) to distribute stresses imposed by traffic to the subgrade. The subgrade properties have a significant influence on the choice and thickness of pavement structure. The nearby existing soils with requisite properties of the subgrade (as desired in MORTH specifications) provides a platform for the construction of subsequent layers and to provide adequate support for the pavement over its design life. Much research has been conducted on the subject of poor soils and their base modification during the past several decades. The present research paper is only emphasising on use of “societies waste materials”, which cannot be reused or is currently environmental burden, in construction of roads, thereby reducing loads on traditional conventional construction materials and reusing the society’s waste materials. The utilization of these waste materials may be an economical alternative but definitely eco-friendly alternative. It will reduce load and pressure from landfills and pressure to reduce energy consumption and green house gas emissions, and thereby technique is suitable for sustainable development.

2.0 Methods and materials

The project under consideration which has been taken as case study is in western Uttar Pradesh, near Delhi in National Capital Region, a stretch of NH 24, Dasna to Hapur road section of Delhi Meerut Express Highway, has diverse geology and consequently a wide variety of soil types throughout the stretch, ranging from fine, alluvial, silty materials clays, fine sand, sandy material and sometimes peat in the floodplains. Need of modification of soil to make it usable for subgrade construction thus also vary considerably throughout the stretch, and local knowledge of the soil types plays an important role in selecting an appropriate waste material which can be obtained locally and also can be used in modification of subgrade without deterring its requisite engineering properties.

3.0 Need for selection of correct waste material

A study was done on locally available waste materials which are treated as waste to society and there are very less takers of them. It is a general practice to dump them in landfills near the city limits, or near the generation areas. The maximum distance of survey was restricted to 30 Km from the road project. The commonly observed wastes (which can be used for mixing in subgrade without negatively affecting its engineering properties) generated near Delhi, Ghaziabad & Hapur districts in state of Western Uttar Pradesh, in National Capital Region (NCR) region of India were identified and listed in Table-1.

Sr	Locally Available Wastes Identified	Distance from site	Nearest captive Locations
1	Fly Ash	15 Km	Badarpur, Dadri TPP
2	Screened MCW- Construction material	22 Km	Ghazipur, Land Fill, Delhi
3	Canal Silt/Sand	12 Km	Ganga Canal, Ghaziabad
4	Rice Husk Ash	12 Km	Burning in farm fields
5	Sugarcane Baggase Husk Ash,	28 Km	Meerut Hapur sugar plants

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6	Cow Dunk Ash	16 Km	Nearby villages
7	Municipal Solid Waste ash	22 Km	Ghazipur, Land Fill, Delhi
8	Sewage Sludge Ash	15 Km	Kondli, Delhi, Indrapuram, GHZ
9	Rubber Tyre Waste	25 Km	Ghaziabad,, Mandi
10	Steel slag	30 Km	Ghaziabad,, Ispat Nagr,
11	Glass	8 Km	Anwarpur Village on road

Table-1 List of Locally available Waste Materials identified with locations and distances from site

4.0 Methodology

The concept of subgrade modification/stabilization with locally available waste materials is discussed everywhere; however, no proper details are available regarding selection of an appropriate method for waste product/s, design of stabilized subgrade, or construction considerations. The present paper is trying to ease the selection of waste additive in subgrade looking to various parameters of wastes generated that is creating environment hazards to the society.

4.1 Selection of Waste Additive

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

4.2 Based on Engineering Properties of modified Subgrade

The major tests which shall be carried out for identification of subgrade properties after mixing with wastes are listed in Table-2. The outcome of these results will help in selection of waste additive in optimum quantities for modified subgrade.

Sr	**Engineering Tests**	**Analysis**
1	Grain-Size Analysis	Calculate the coefficient of uniformity
2	Liquid and Plastic Limits	To obtain the value of PI (Plasticity Index)
3	Free Swell Index	It indicates the cracking behaviour 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 on the material at varied moisture contents
B	Optimum Moisture Content (OMC)	The moisture content at which the maximum dry density is obtained
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
8	E-Value	Elastic Modulus the flexural strength of casted beam

Table-2 Engineering Tests to be conducted for performance assessment of subgrade

4.3 Based on other Indicators

There may be many indicators other than engineering properties. For analysis only 5 indicators are considered for benefit analysis, listed in Table-3. The indicators selected were as listed in Table-3.

Sr	Indicators	Scale of Measurement
1	Cost of Transportation to the site	Scale will be 1 to 5, with 5 will be most expensive and 1 will be free
2	Cost of material at Source	Scale will be 1 to 5, with 5 will be most expensive and 1 will be free
3	Cost of Mixing at Site	Scale will be 1 to 5, with 5 will be most expensive and 1 will be Minimum
4	Availability	Scale will be 1 to 5, with 5 will be least available and 1 will be available in abundance
5	Environment Hazard scale	Scale will be 1 to 5, with 5 will be most severe and 1 will be least effective

Table-3 List of Indicators with Scale of Measurement

5.0 Methodology

After identification of waste materials as listed in Table-1, which can be used as modifiers to be used in subgrade the rubber tyre, glass and steel slag were removed for consideration as they are reusable material hence are having cost of procurement.

The method of Evaluation for selecting the Waste Material is based on scorecard (SC) which is a strategy performance management tool. Based on Table-3 indicators and scale of measurement the results obtained are listed in Table-4, as under:

Sr	Locally Available Wastes	Cost of Transport to the site	Cost of material at Source	Cost of Mixing at Site	Availability	Environment Hazard scale	Total
1	Fly Ash	2	0	2	1	5	10/25
2	Screened MCW-Construction material	4	2	3	1	2	12/25
3	Canal Silt/Sand	1	1	1	1	2	6/25
4	Rice Husk Ash	1	1	2	3	4	11/25
5	Sugarcane Baggase Husk Ash	5	1	2	3	4	15/25
6	Cow Dunk Ash	2	5	2	5	3	17/25
7	Municipal Solid Waste ash	4	0	3	2	5	14/25
8	Sewage Sludge Ash	2	0	3	3	5	13/25

Table-4 (List of Indicators with Scorecard)

6.0 Results and Discussion

The performance output is calculated based on “indicators”, “outcomes”, and “matrix metrics”, from Table no -5 with order of preference is as under:

Order of Preference	Locally Available Wastes
1	Canal Silt/Sand
2	Fly Ash
3	Rice Husk Ash
4	Screened MCW- Construction material
5	Sewage Sludge Ash
6	Municipal Solid Waste ash
7	Sugarcane Baggase Husk Ash,
8	Cow Dung Ash

Table-5 (Order of Preference in accordance with indicators mentioned in table-3)

The selection criteria shall have a combination of both indicators and test results (obtained from Table-2, Engineering Tests to be conducted for performance assessment of subgrade) and their interrelationships, however as this paper is only dedicated to Environment Management in Civil Engineering, hence only indicators have been evaluated on scorecard technique and not the engineering tests.

The combinations of tests would have very complex matrix, hence been avoided here and left for further research with other mathematical models.

7.0 Conclusions:

Relative score concludes that the material having the lowest score shall be preferred as waste material to be used in subgrade; however it shall not deter the properties of subgrade soil, negatively. It can be used in combination with last two lowest score materials or with last three too.

Climate change can be avoided by adopting sustainable development with singularly approach of reducing the consumption of natural resources. As road infrastructure development consumes large amount of energy and natural resources, an emphasis is much needed to be given on new and innovative construction technologies, development to reduce wastage, by reusing of waste materials to its most. Waste management has to be adopted through prevention, minimization, reuse, recycle and recovery. Waste has to be converted into a resource for sustainable development. Everyone needs to contribute in reduction of greenhouse gases in some way or the other, but sustainable development is based on human needs and thus has to be considered more by those in higher level of needs as they consume considerable natural depleting resources.

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