A CRITICAL REVIEW OF INNOVATIVE RURAL ROAD CONSTRUCTION TECHNIQUES AND THEIR IMPACTS

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Rural Roads Connectivity is one of the key components for rural development, as it promotes access to economic and social services, generating increased agricultural income and productive employment. While building rural roads, the provisions based on the parameters that affect the sustainability are to be made, but at minimum cost. The conventional methods and specifications tend to recommend technology and materials, however difficult and distance away they may be, which normally result in higher cost of construction. It is the duty of the engineers to spend every rupee of the taxpayer's money with optional utility particularly under resource constraints. This call for introduction innovative approaches in rural roads building for achieving cost-effectiveness. Though such methods and technologies were tried world over, they could not become popular in India, due to procedural constraints and lack of awareness/exposure. At this juncture, an attempt is made to bring in together innovative technologies and discuss their positive impacts so as to convince the field engineers in adopting such technologies at placed found effective.

1. INTRODUCTION

About 600 million people of India live in nearly 6 lakh villages scattered all over the country. Access roads provide the means to bring the rural population on to the main stream. Notwithstanding the efforts made, over the years, at the State and Central level, through different programmes, about 40% of habitations in the country are still not connected by all-weather roads. As a Poverty reduction strategy, PMGY was launched as a 100% centrally funded programme for Rural Roads Development in India. The rural connectivity is expected to have many positive impacts on economy, agricultural, employment and social services to rural masses.

India is distinguished for its geographical diversities with mountains, hills, rivers terrains, forest, wet lands, deserts and scattered habitations in remote areas. Also, there exists a wide range in the sub-grade soil types, rainfall, traffic pattern and availability of construction materials.

These natural barriers create problems for developing a standard uniform technique to serve the requirements at all the sites. This requires adoption of different technologies based on site specific conditions.

For the construction of Rural Roads, Indian Roads Congress has brought out Rural Road Manual IRC SP:20-2002 for design and construction. The design is based on the CBR value of the soil sub-grade and the 10 years projected cumulative traffic with an assumed 6% traffic growth per year. Based on this concept, normally two layers of WBM with 75 mm thickness is laid over the granular sub-base with suitable material having minimum 15% CBR. However, there are situations in many states where the prescribed standards are not available at normal leads resulting in longer haulage and higher costs.

If the locally available materials, including marginal and industrial waste materials are utilized, it could be possible to reduce the cost of road construction. Several types of new materials are tried to establish the efficacy of new materials in road construction. However,

the use of new materials and technologies is not becoming popular owing to certain procedural constraints as well as lack of awareness and therefore appropriate steps may have to be taken for popularizing the new technologies for building better rural roads with less cost. Adoption of such technique may also result in the conservation of natural resources, energy environment.

2. GROUND IMPROVEMENT TECHNIQUES

One of the proven technologies for the use of local soil and marginal aggregates is stabilization. The stabilization can be mechanical or chemical and several types of stabilizing agents have proved to be suitable under different conditions of soil and environment. The soil stabilization techniques include:

- Stabilization with lime.
- Stabilization with cement.
- Stabilization with a combination of lime and cement

Even though specifications for soil stabilization are included in both MoRT&H and MoRD book of specifications their adoption is not getting popular, due to problems associated in attaining homogeneity of soil-stabilizer mix in the field and achieving the desired results. The only constraint in the use of the above techniques lies on the procedures adopted in the field. It is possible to popularize the use of stabilization techniques through appropriate training and capacity building of the field engineers. Further, development of low end technology equipment, for use in the rural roads also facilitates wider use of these methods.

In addition to the above, several methods are being tried with the use of industrial waster by products in road building. The following are some of the important materials which have proved good.

- Fly Ash for the construction of the embankments and stabilization of sub-base and base-courses.
- Steel and copper slags for the construction of sub-base and base-courses.
- Marble dust in sub-grade and sub base.

Though the construction of different elements of the road with Fly Ash has been successfully implemented, the use of other materials is not so widely adopted except for in-plant roads. However, construction technologies with the use of such materials can also be successfully adopted, if the field engineers are properly trained.

Studies were carried out on the use of waste materials like rice husk ash and lime sludge. These materials, if left un-used, may affect the surroundings and also create problem for their disposal. Use of those waste materials in road construction can alleviate the problem of their disposal to great extent. In India, studies were conducted at CRRI, IIT Roorkee and several other places for their use in stabilizing the soil. The results indicated that heir usage has great impact on the improvement of soil properties. The studies suggested that they are very useful for stabilizing clayey soils. The summary of the results indicate the following.

- Improve Atterberg limits to make soil suitable for road building.
- Increase the unconfined compressive strength of soil as well as CBR.

3. INNOVATIONS IN GROUND IMPROVEMENT

Recently several environmental friendly enzymes have come into the market such **Fujibeton, Terrazyme** and **Renolith** etc. Use of these products indicates minimization, elimination of the use of aggregates and is referred to as Aggregate-Free Pavement Technology. Such materials can also be tried in the rural roads construction after proving their efficacy in the Indian conditions, through series of trial projects.

3.1 Fujibeton as a Soil Stabilizing Agent

The Fujibeton material, developed in Japan, is climatically stable material and suitable for stabilization of all types of soils. Basically, the product is an inorganic polymer that chemically binds with all compounds, where blended with ordinary Portland cement in 1 to 3% by weight of OPC. The blended mix is called **'Fujibeton Mix'**, which is used for stabilization of soil that improves the engineering properties of soil.

The design concept is based on the optimization of Fujibeton mix for stabilization based on unconfined compressive strength results determined on the given soil for different proportions of soil-Fujibeton mix and calculation of the thickness of the stabilization layer (Beton-Sub-base) based on design CBR, wheel load and volume of traffic. The top layer of the pavement should be covered with 3 to 5 cm asphalt concrete.

The technology is advantageous not only for locations where aggregates are not available at economical rates but also for all types of soil conditions. With the use of new soil hardening agent, the material available at the construction site may be used as it is, eliminating the need for transporting of borrow soil from long distances, thus economizing and simplifying the work process. Fujibeton improves CBR of the sub-grade and does not create shrinkage cracks and is therefore highly effective for clayey/soils. With Fujibeton, a high dry density is obtained with only minor compaction. Therefore, small and simple equipments like tractor mounted equipment are sufficient. Also, this technology does not require skilled manpower for road construction. This technology is efficient and economical for construction of embankment and sub-grade & sub-base course.

Experimental Study in India

To evaluate the performance of this technology, using Fujibeton as soil stabilizer, small road stretch has been constructed within the campus of NCCBM's in Ballabhgarh. With this study, it is revealed that because of faster setting and improved CBR of stabilized soil, the rural road can be opened to traffic within a day. Due to speedier construction practices, the Fujibeton-stabilized rural roads will not only be economical but also prove to be effective under constraints of traffic diversion.

3.2 Terrazyme as a Soil Stabilizing Agent

Terrazyme is a natural, non-toxic; environmentally safe, bio-enzyme product that improves engineering qualities of soil reduces ruts and potholes resulting in more durable and longer lasting roads. The function of Terrazyme is to minimize absorbed water in the soil for maximum compaction, which decreases the swelling capacity of the soil particles and reduces permeability. The application of Terrazyme enhances weather resistance and increases load-bearing capacity of soils especially in clayey/soils. This will provide cost effectiveness both in the initial construction cost and maintenance cost.

Advantages of Terrazyme Technology:

- Considerable improvement in soil CBR.
- Minimum loss of gravel due to erosion or abrasion by the traffic preserving original transverse section of slopes.
- Impediment of widespread occurrence of dust from loose fine material on the road surface.

Terrazyme is used world wide in strengthening of layers of un-surfaced roads, in base layers and sub-base layers covered with asphalt material. Among the soil materials stabilized by Terrazyme are sandy clay, silty clay, sandy silt, plastic and non-plastic clay, sandy loam, fine loam, loam mixed with clay.

Case Studies in India

Trial roads were built in India with Terrazyme stabilized road structure in the states of Kerala and Tamil Nadu. The soil used in these studies are mainly gravelly clay, silty clay, clayey sand, medium to fine sand-clay mixtures, silt and clay mix. It is proved that there is an increase in CBR value of more than 100% and Relative compaction by more than 100%.

Case study of the two roads built by PWD of Maharashtra revealed that the use of Terrazyme resulted in overall cost savings in the range of 18-26%.

3.3 Soil Cement Renolith Stabilization Technique:

Renolith is polymer based chemical, which is environmentally friendly and which facilitates the bonding of soil particles (a phenomenon which is known a micro-rubber bonds). Soil-cement with Renolith has a high modulus of elasticity and can disperse the wheel loads very effectively. It is a semi-rigid material. A noteworthy feature of this technology is that it require very little amount of aggregate, which is useful at places where the material haulage is more. The use of Renolith, when used in soil stabilization with cement, gives strong and durable base. This type of construction does not require surfacing for low volume roads, since the base course is stabilized. It is expected to give good performance with longevity and reduces maintenance costs in almost dust free environment. Limited research was carried out abroad, with soil cement Renolith Stabilization, but similar studies are yet to be carried out in India.

4. ALTERNATE TECHNOLOGIES IN RURAL ROADS CONSTRUCTION

There are several other techniques that can be adopted in conditions of low bearing capacity soils, marshy lands and location with drainage problems such as the use of geo-textiles. Several types of geo-textiles including synthetic, jute coir etc. are proved to give good results and provide cost effectiveness for rural roads.

4.1 Use of Jute Geo-textile

Jute Geo-textile (JGT) is a kind of natural technical textile laid in or on soil to improve its engineering properties. It is made out of yarns obtained form the jute plant. Jute Geo Textiles have high moisture absorption, excellent drapability, high initial tensile strength, bio-degradable and improved soil structure on degradation. The basic functions of JGT are separation, filtration, drainage and initial reinforcement. It is environment friendly. Jute Geo-textiles can be more effective, eco-friendly and economical if used judiciously and jointly with other measures.

Based on the experiences of the use of Jute Geo Textiles, MoRD in collaboration with JMDC is implementing a pilot project in five States covering a length of about 48 Km under different soil and environmental conditions.

This project is taken up with different types of Jute Geo-textile and placement at different levels. The post construction performance monitoring is expected to give valuable data for arriving at standards and specifications of this technique which helps for wider application. The project is in progress and the results are expected shortly.

States	Total length of Roads (Km)	(Cost in lakh)		Savings in Rs. lakh
		Conventional Design	With Jute Geo Textile	
Assam, Chattisgarh, Madhya Pradesh, Orissa, West Bengal	47.84	2022.95	1790.06	232.89

4.2 Flexible-Concrete Pavement Technology

IIT Kharagpur has developed a new technology for low cost cement concrete road construction, which has proved to be suitable in place of conventional CC roads for low volume traffic. Even though the initial cost of flexible-concrete road is high compared to cost of conventional flexible pavement, the life cycle cost with maintenance costs over a period of 10-20 years is less compared to the conventional one. The technology consists of placing a form work of plastic cells 150 x 150mm and 100mm deep over the prepared foundation of road and placing zero slump concrete in the cells and compacting with road roller/ plate compactor / earth rammer. On curing, a flexible-concrete pavement is obtained which will not wear even under iron tyred carts if aggregates of good quality are used. A model rode has already been constructed in a village close to IIT Kharagpur using the technology "IITGP_ROAD"

Experimentation through pilot project for the "IITGP_ROAD" technology is being tried I the construction of the rural rods under PMGSY, so as to enable standardization and popularization of this cost effective solution.

4.3 Use of Waster Plastic Blended Bitumen

It is possible to improve the performance of bituminous mixed used in the surfacing course of roads. Studies reported in the used of re-cycled plastic, mainly polyethylene, in the manufacture of blended indicated reduced permanent deformation in the form of rutting and reduced low – temperature cracking of the pavement surfacing. Laboratory studies were carried out at the Centre for Transportation Engineering of Bangalore University, in which the plastic was used as an additive with heated bitumen n different proportions (ranging from zero to 12% by weight of bitumen) The results of the laboratory investigations indicated that, the addition of processed plastic of about 8.8% by weight of bitumen, helps in substantially improving the stability, strength, fatigue life and other desirable properties of bituminous concrete mix, even under adverse water-logging conditions. The additions of 8.0% by weight of processed plastic for the preparation of modified bitumen results in a saving of 0.4% bitumen by weight of the mix or about 9.6% bitumen per cubic meter of BC mix.

Case Studies in India:

- In Tamil Nadu, length of roads around 1000 m in various stretches were constructed using waste plastic as an additive in bituminous mix under the scheme "1000 km Plastic Tar Road", and found that, the performance of all the road stretches are satisfactory.
- The performance of the road stretches constructed using waster plastic in Karnataka is also found to be satisfactory.

The construction of rods using Waste Plastic in the above states is based on the guidelines developed by Bangalore University. CRRI and College of Engineering, Madhurai. However, standard specifications are not available on the use of waste Plastic in Bituminous road Construction. In this regard, IRC was specially requested by NRRDA for the preparation of such Guidelines for enabling the construction of Rural Roads under PMGSY using Waster Plastic. In order to facilitate the development of Guidelines on this, an Expert Group has been appointed by NRRDA for preparation of interim guidelines for the use of Waste plastic which will be sent to IRC for approval and releasing as IRC guidelines.

5. IMPACTS OF INTRODUCING INNOVATIVE TECHNOLOGIES

The stabilization of soil with Enzyme based stabilizers like Fujibeton, Terrazyme and Renolith, can eliminate the need for the use of aggregate material in base course resulting in conservation of material. This results in reduction in the cost of construction. A typical analysis for saving of cost in terms of material, machinery and labour for two layers of WBM (75 mm each) and 3.75 m carriageway indicate a saving of about Rs. 5.0 lakhs with medium lead.

It Is not only the reduction of cost, but the real interesting part of this is the conservation of natural resources and energy along with preservation of the environment, which gives long way, if such aggregate free construction of rural roads are encouraged and popularized.

6. CONCLUSION

From the above discussions, the following conclusions can be drawn:

- Fujibeton can used to improve CBR for the sub-grades by about 2.6 times. Simple tractor mounted agriculture equipment can be employed for construction and Economy in construction when aggregates are to be brought from far off distance as well as due to reduced thickness of sub base / base course.
- Terrazyme increases CBR of soil sub-grade by more than 100%. Impedes widespread occurrence of dust from loose fine material in the surface of the soil roadways and reduces cost of construction by 15-20%. The roads constructed using Terrazyme minimizes the material loss of gravel from erosion or abrasion by the traffic on the soil roadways preserving original transverse section and slopes and impedes widespread occurrence of dust from loose fine material in the surface of the soil roadways.
- The noteworthy feature of soil-Cement-Renolith Stabilization that it requires very little amount of aggregate, performs with increased life and reduced maintenance cost provide a good base for the field Engineers to experiment the construction of unsealed roads in rural areas and also in localities where aggregate are not available in normal leads.

- The Jute Geo-textile strengthens the soil sub-grade by preventing intermixing of sub-grade and sub-base by acting as a separation layer and further it prevents migration of fines of a sub-grade by acting as a filtration materials. By the pilot project taken up under PMGSY, it is found that there is cost saving of about 12% in road construction.
- The "IITGP_ROAD" technology need to be studied further because even through, the initial cost of Cement Concrete Pavement is at par with the conventional pavement, it is lower than the conventional flexible pavement if maintenance cost is also considered whose bitumen top is to be renewed every 5 years at a cost of over 5 lakhs.
- The use of modified bitumen with the addition of processed waste plastic of about 8.0% by weight of bitumen helps in substantially improving the stability, strength, fatigue life and other desirable properties of bituminous concrete mix, resulting which improves the longevity and pavement performance with marginal saving in bitumen usage.

7. RECOMMENDATIONS

The use of new materials and technologies is not becoming popular in our country mainly due to lack of awareness. Failure to instill confidence in the field engineers by addressing their problems can be another reasons, the third being non-availability of suitable standard equipments.

In the light of the fact that efficacy of innovative technologies was established in several case studies taken under varied conditions, time is opportune to initiate the construction of "Technology Demonstration Projects". During the implementation of such Projects the field engineers are to be taken into confidence and need to be involved eight form Project Preparation. All technical and implementational processes are to be meticulously documented which become handy in the disseminations process for exposing more field engineers to the technologies. This will instill confidence among them and large scale adoption of these technologies would become possible. The successful demo of these projects also brings out the cost effectiveness and conservation of natural resources that may lead to environmental preservation in the long run.

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