Innovative Construction Technology for Quality Construction of Rural Road

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Rural Connectivity becomes a critical component in the socio-economic development of rural people by providing access to amenities like education, health, marketing etc. It has been established that investments in rural roads lifts rural people above the poverty line. The evidence also indicates that as the rural connectivity improves, the rural poverty levels come down. 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. Quality Construction of rural road has been a major challenge for engineering fraternity all over the world. This call for introduction of innovative and environment friendly 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. In this paper author has made an attempt to present innovative, cost effective and environment friendly technology for quality construction of road. National scenario presents an interesting picture. Economic and environmental aspects were also discussed.

Rural development has become a matter of growing urgency for considerations of social justice, national integration, and economic upliftment and inclusive growth. For rural development, the provision of rural road network is a key component to enable the rural people to have access to schools, health centers and markets. Rural roads serve as an entry point for poverty alleviation since lack of access is accepted universally as a fundamental factor in continuation of poverty. As India launched the era of planned development in 1951, she had a reasonably good railway system, a few ports and around 400,000 kms of serviceable road network. Accessibility to villages was poor as only about 20 percent of them had all-weather road links. The Government laid down a framework for accelerated growth through investments in irrigation, power, heavy industry and transport. Side by side, stress was laid on provision of social infrastructure (education and health) and integrated rural development including agriculture. Rural roads act as a facilitator to promote and sustain agricultural growth, improve basic health, provide access to schools and economic opportunities and thus holds the key to accelerated poverty reduction, achievements of Millennium Development Goals (MDG), socio-economic transformation, national integration and breaking the isolation of village communities and holistic and inclusive rural development. A major thrust to the development of rural roads was accorded at the beginning of the Fifth Five Year Plan in 1974 when it was made a part of the Minimum Needs Programme. In 1996, this was merged with the Basic Minimum Services (BMS) programmes. The works of village tracks were also taken up under several employment creation and poverty alleviation programmes of the Central and State Governments.

There is growing empirical evidence that links transport investment to the improved well being of the poor. A study (Fan, Hazel and Throat, 1999) carried out by the International Food Policy Research Institute on linkages between government expenditure and poverty in rural India has revealed that an investment of ₹ 10 crore (at 2009-10 prices) in roads lifts 16,500 persons above the poverty line. States having low connectivity had higher poverty levels. Provision of good roads in rural areas also changes the characteristics of rural transport. With people tend to travel more, the ownership of vehicles increases. There is a shift from non-motorized vehicles to motorized ones and the cost and time of travel get reduced.
Presently about 740 million people of India live in rural area. Rural connectivity is being focused for the growth of economy, agricultural development and employment generation to rural people. India is having about 2.65 million km of road under rural road category out of total road network of 3.3 million km according to a statistic of Indian road network of National Highways Authority of India. Efforts are going on by central government and state government through different program like Pradhan Mantri Gram Sadak Yojana (PMGSY) to improve road access to rural people. Still about 40 percent of village people of the country are not connected by all weather roads. 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 and environment.

**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 waste 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 inplant 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 unused, 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.
Innovations in Ground Improvement

Recently several environmental friendly enzymes have come into the market such as 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.

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-Subbase) 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.

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 loadbearing 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.

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.

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 geotextiles. Several types of geo-textiles including synthetic, jute coir etc. are proved to give good results and provide cost effectiveness for rural roads.

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, biodegradable and improved soil structure on degradation. The basic functions of JGT...
are separation, filtration, drainage and initial reinforcement. It is environment friendly. Jute Geotextiles can be more effective, eco-friendly and economical if used judiciously and jointly with other measures.

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.

3. Use of Waster Plastic Blended Bitumen

It is possible to improve the performance of bituminous mixed used in the surfacing course of studies. Reports indicated in the use 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.

4. Cold Mix Technology

Cold mix is a mixture of unheated aggregate and emulsion or cutback and filler. The main difference between cold mix and HMA is that aggregates and emulsion or cutbacks are mixed at ambient temperature (10°C-30°C) in case of cold mix and aggregates and binder are mixed at high temperature (138°C-160°C) in case of HMA. Dense graded cold mixtures have far lower permeability and good resistance to deformation. Open graded mixtures are storable and semi dense mixtures have good adhesion and lower permeability.

Cold mix when used as paving mix can offer following advantages.
- It eliminates heating of aggregate and binder.
- It is environmental friendly and conserves energy. Cold mix pavement can provide energy savings of over 50% compared with hot mix. So it can be considered as green bituminous mix for rural road construction.
- It can be easily prepared using small set up on site. It can be produced manually for small scale job. Laying of HMA for rural road construction sometimes is not economical because setting up of a hot mix plant for small scale job increases the project cost.
- This paving mix is particularly suited for construction of roads in remote and isolated areas of a country where plant produced hot mix may have set before reaching site.
- Cold mix can be laid during wet or humid condition also.
- It is versatile also as a large number of grades of emulsion and cutbacks are available.
- It is economical and high production is possible with low investment

In India majority of road network is occupied by bituminous pavement only in which Hot Mix Asphalt (HMA) is used predominantly as a paving mix from many decades. However this bituminous mix is associated with some limitations. These include excessive emission of greenhouse gases (e.g. sulfur dioxide, nitrogen oxides, carbon monoxides and volatile organic compounds) from HMA plant, shut down of hot mix plant during rainy season and the laying of HMA is difficult in hilly areas and rural areas having long hauling distances, cost of putting up HMA plant is high and comparative budgets of small sections of rural road is very less, etc.

As, Indian rural road network is developing continuously, paving mix like cold mix asphalt or Warm Mix Asphalt (WMA) should be tried. This mix is started to lay on pavement to reduce the problems associated with HMA. Warm mix asphalt is a very new technology compared to cold mix asphalt.

Construction of rural road using conventional paving mix is sometimes not feasible in high rainfall area because it is difficult to produce and lay HMA. In case of high altitude or snow bound area, lower temperature of environment makes difficult to heat aggregate and binder at high temperature. In case of hilly roads, HMA is supplied from remote HMA plant; it is difficult to maintain mix temperature for long hauling distance. Cold mix can be produced on
site. Simple concrete mixture, motor pavers or specialized mixing plant can be used to produce cold mix on site. Cold mix can be lay down by hand for small scale job and compaction is carried out by vibrating roller. Hence Cold mix asphalt should be tried in India for construction of rural roads in hilly areas having high rainfall and difficult terrain.

National Scenario

1. Fujibeton as a Soil Stabilizing Agent: 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 Ballabghar. 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.

2. Terrazyme as a Soil Stabilizing Agent: 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. Use of Jute Geo-textile: Based on the experiences of the use of Jute Geo Textiles, MoRD in collaboration with JMDJ 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.

4. Flexible-Concrete Pavement Technology: A model road 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 for the construction of the rural roads under PMGSY, so as to enable standardization and popularization of this cost effective solution.

5. Use of Waster Plastic Blended Bitumen:

- 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 waste plastic in Karnataka is also found to be satisfactory.

The construction of roads using waste plastic in the above states is based on the guidelines developed by Bangalore University. CRRI and College of Engineering, Madurai. However, standard specifications are not available on the use of waste plastic in bituminous road construction.

5. Cold Mix Technology: North eastern states of India belong to hilly area and sometimes roads go through forest zone. Due to its topographical constraints and environmental rule and regulation, use of cold mix may be a promising mix under different site conditions. Field trials have been carried out by CRRI at some location in North eastern states of India. Cold mix is gaining considerable popularity in rural road construction.

Economic and Environmental Aspect

- 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.

- Using Jute Geo-textile in the pilot project taken up under PMGSY, it is found that there is cost saving of about 12% in road construction.

- MoRD in collaboration with JMDJ is implementing a pilot project in five States covering a length of about 48 Km under different soil and environmental conditions, the cost analysis of which is given below:

- 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 “IITGP_ROAD” technology need to be studied further because even though, 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 additions of 8.0% by weight of processed plastic for the preparation of modified bitumen results in a...

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saving of 0.4% bitumen by weight of the mix or about 9.6% bitumen per cubic meter of BC mix.

- 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.

- It can be laid as surface course or bituminous base course for rural road construction.

- Cold mix can be tried for paving mix in north east region of India.

- Large scale laboratory and field trials studies should be carried out to develop better understanding on the performance of cold mixes in rural road construction for different traffic, climate and terrain conditions.

- 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.

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

**Conclusion**

- Fujibeton improves CBR of the sub-grade and does not create shrinkage cracks and is therefore highly effective for clayey soils.

- 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 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.

- 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.

- Cold mix can be laid on low to medium volume road as a green paving mix. Mixture can be produced by using conventional plant or by hand. So it can be laid as surface course or bituminous base course for rural road construction.

- Large scale laboratory and field trials studies should be carried out to develop better understanding on the performance of cold mixes in rural road construction for different traffic, climate and terrain conditions.

- 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.

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