International Journal of Constructive Research in Civil Engineering (IJCRCE)
Volume 1, Issue 2, July - September 2015, PP 11-15
www.arcjournals.org

Framework for Durable and Economical Construction of Rural Roads in India

Achal Garg
Dept of Structural Engineering
Keppel Offshore and Marine Engineering,
Mumbai, India.
achalgarg_1992@yahoo.com

Harinder Yadav
Department of Civil Engineering
University of Petroleum and Energy Studies
Dehradun, India.
princeharry62@gmail.com

Abstract: *Rural road connectivity is one of the key components for rural development in Indian context, as it promotes access to economic and social services, generating increased agricultural income and productive employment in various parts of the country. The conventional methods and specifications tend to recommend products and technologies, however difficult and distance away they may be, which normally results in higher cost of construction, could not become popular due to procedural constraints, lack of awareness, and exposure. At this juncture, an attempt is made to bring in together innovations and discuss their positive impacts so as to convince the field engineers and stakeholders in adopting the effective products and technologies. The rural roads asset created using the valuable environmental resources such as precious soil, stone, and other products, it has to be maintained to deliver the desired level of service in the design life. In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. The use of these materials in road construction is based on various technical, economic, and ecological criteria for which a critical review has been presented in this paper.*

Keywords: *Construction, Durability, Economy, Environment, Rural Development.*

1. Introduction

The connectivity of rural roads is a key component of rural development in any country around the globe, since it promotes access to economic and social services, thereby generating increased agricultural productivity, non-agriculture employment as well as non-agricultural productivity. It also expands rural growth opportunities and real income through which poverty can be reduced. It is a well-known fact that Indian road network at over 3.3 million km falls under one of the world's longest road networks. According to the government statistics, by year 2000, India had connectivity to almost all villages with populations of over 1500, 86 percent with 1000 to 1500 inhabitants, and 43 per cent of villages with less than 1000 population and successive plans aimed at achieving higher road densities and managed to over achieve it. Even though, the total length of rural roads targeted at the end of the Lucknow Plan (1981-2001) of road development appeared to be large, it must be noted that almost 100,000 km of the roads were constructed under different employment generation schemes and poverty alleviation programs such as Food for Work, National Rural Employment Programme and Jawahar Rojgar Yojana and others. The roads were of indifferent quality constructed by semi-skilled or unskilled labour. The objective of these programs was provision of sustenance support to the rural people in the country. The technical standards of asset quality were not insisted upon and construction was often restricted to earthen tracks with no provision even for cross drainage or side drainage during planning or construction phase. Rural roads have suffered greatly due to lack of systematic planning. While rural road development plans provided for a network structure and target lengths of different types of roads, specific connectivity requirements of individual settlements such as type of villages and habitation and issues of regional imbalances were not adequately addressed. This led to more than one connection for the same village resulting in redundancy and development of a large unmanageable network under the scheme. While constructing rural roads, adequate care was not taken in adopting need based economical designs, parameters for selection of pavement and the construction technology, quality assurance, and quality control throughout the construction process. Multiplicity of organizations involved in the rural roads development led to uncoordinated efforts, ad-hoc decisions, and a poorly managed network structure.

2. RURAL ROAD INFRASTRUCTURE IN INDIA

Rural roads are the basic infrastructure requirement and play a vital role in socio-economic upliftment of the rural community in Indian scenario. They contribute significantly in rural development by creating opportunities to access goods and services located in nearby villages or major town and market centers. Provision of rural roads increases mobility of men and materials thus facilitating economic growth in the rural context of the economic cycle. Better rural infrastructure has primarily two effects in the development agenda – first is the promotion of economic growth and second is decline in the incidence of poverty. Some empirical studies illustrate a strong relationship between infrastructure development which combines both rural and urban, and economic growth. According to a study presented by World Bank, 1% increase in infrastructure stock is associated with a proportionate increase in GDP across all countries. A specific sectored study by Deichman et al for Mexico shows that a 10% increase in market access leads to increase in labour productivity by 6%.

Rural roads are part of the total road network system and basically consist of various categories such as National Highways, State Highways, Major District Roads, Other District Roads and Village Roads in Indian context. As per the definition of Indian Roads Congress (IRC-SP: 20: 2002) rural roads includes Other District Roads (ODR) and Village Roads (VR) as tertiary system for providing accessibility in rural areas. Rural roads, therefore, become links of a network, which facilitate the movements of persons and goods in an area. There are several other interconnecting routes also exists in rural areas. A road network, therefore, needs to be developed in such a way that the travel needs of the people in an area are met to the maximum extent in a collective way at the lowest cost of development making the whole plan economical. In rural areas major part of travel needs comprises of travel to market place, education and health centers, and community centers. Planning of a road network system should always focus on spatial aspect of planning and should be integrated with other non-spatial socio-economic activities. Roads have to be planned and programmed in such a way that all villages and habitations are connected in an optimal way to achieve efficient flow of traffic and accessibility and fulfilling basic needs of the occupants. In the past, rural roads have been constructed under various rural road development programs, which are mainly conceived for employment generation and poverty alleviation by the state and central governments. In such programs, all the efforts were failed to build sustainable all-weather roads as the roads were never considered to be engineering structures and these not designed to the required specifications. The roads built under these programs without back-up system or facility to sustain them with engineering inputs for repair and maintenance in the life-cycle, have disappeared in no time. Many of the technical aspects of road construction for example, adequate compaction of sub-grade, roadside drainage and required cross drainage were seldom given due importance in context of rural road construction. The design of rigid pavement of rural roads including that of block pavements and roller compacted cement concrete have been brought by the Indian Roads Congress (IRC) is being recommended for implementation of rural road development program at present.

3. PERFORMANCE AND SELECTION CRITERIA FOR PAVEMENTS

Water in pavement systems is one of the principal causes of premature pavement failure. Most of the roads built in India have very slow draining systems, largely because standard design practices emphasizes on density and stability but place little importance on sub-surface drainage aspect which leads to large amount of costly repairs or replacements long before reaching their design life. Sub-surface drainage is a key element in the design of pavement systems while selecting the type of pavement for a road construction and assessing its performance and life-cycle. Excessive water content in the pavement base, sub-base, and sub-grade soils can cause early distress and lead to a structural or functional failure of the pavement, if counter measures are not undertaken. Performance is a general term for how pavements change their condition or serve their intended function with accumulating use in design life. Performance means something different when it is used at project level or on a network level. At project level, performance is defined by the distress, loss of serviceability index and skid resistance, loss of overall condition, and by the damage that is done by the expected traffic after the road construction.

Pavements are typically divided into the following three general categories which are flexible, rigid, and unpaved (gravel or dirt). Flexible pavements are constructed of several layers of natural granular material covered with one or more waterproof bituminous surface layers. As the name imply, it is considered to be flexible. A flexible pavement will flex or bend under the load of a tyre imposed by the vehicles. The objective with the design of a flexible pavement is to avoid the excessive flexing of any layer, failure to achieve this will result in the over stressing of a layer, which ultimately will cause the pavement failure. In flexible pavements, the load distribution pattern will change from one layer to another as the strength of each layer is different. The strongest material which is least flexible is used in the top layer and the weakest material which is most flexible is used in the lowest layer of pavement. The reason for this is that at the surface the wheel load is applied to a small area resulting high stress levels and deeper down in the pavement, the wheel load is applied to larger area resulting in lower stress levels thus enabling the use of weaker materials. In comparison to flexible pavements, rigid pavements are composed of a PCC surface course which is substantially stiffer than flexible pavements due to the high modulus of elasticity. Furthermore, rigid pavements can have steel reinforcement which is generally used to reduce or eliminate joints which allows the placement of rigid pavements on relatively weak supporting layers, as long as the supporting layer material particles will not be carried away by water forced up by the pumping action of wheel loads.

4. COST ANALYSIS OF RIGID AND FLEXIBLE PAVEMENTS

Since road pavements are an important part of rural road development projects, costing about 50% of the investment, a careful evaluation of the alternatives is necessary to make the right choice on a rational basis, which may be comparatively more beneficial to the nation. Flexible pavements have been the preferred choice because of low initial cost as compared to the rigid pavements for rural road construction plan. In view of availability of cement in plenty within the country and scarcity and rising prices of bitumen as crude oil prices in the international market are rising and bulk of crude oil has to be imported from other countries, it has become prudent to consider rigid pavement, a far better alternative to flexible pavement. The superiority of rigid pavements over flexible pavements is well recognized the world over and many developed countries have already constructed long stretches of concrete roads to meet the increasing passenger and freight traffic on high traffic corridors. The initial cost or investment in construction of the concrete pavement on rural link roads is more by about 25% over the flexible pavement, but in life cycle costing concrete pavement has proved to be economical over flexible pavement.

The selection criteria of type of pavement, flexible or rigid, should be based not on the initial cost of construction but life cycle cost, which includes the discounted maintenance and pavement strengthening costs that are incurred during the design life of the pavement. The life cycle cost analysis can be defined as a procedure by which a pavement design alternative will be selected, which will provide a satisfactory level of service at the lowest cost over design life. A study has been conducted in this regard considering the average yearly maintenance cost of rigid pavement of about Rs. 10,000 per km for a single lane rural road to cover filling of sealing compound in the joints and repairs. The period of analysis considered as 20 years, being the design life of concrete pavement in rural area. The discount rate of 10% and an inflation rate of 5% considered for future rise in prices of materials. The results of the study presents that the initial cost of a concrete pavement is around 9000 USD per km (28%) higher over the initial cost of a flexible pavement. However if fly ash (30%) is used to replace cement in concrete, the extra cost of concrete pavement is 6375 USD per km. The life cycle cost of a concrete pavement for construction and maintenance costs is however 7950 USD per km (19%) less compared to flexible pavement. In case of fly ash mixed concrete, the concrete pavement cost is 10650 USD per km (27%) less compared to flexible pavement. Although the initial cost of concrete pavement is higher as compared to the bituminous pavement but life cycle cost of concrete pavement is about 22-25% lower than bituminous pavement. Besides life cycle cost consideration, several locations should be preferred for rigid pavement from climatic and environmental considerations such as locations in heavy rainfall, waterlogged areas and road stretch passing through village portion, having cement and fly ash in close proximity or sub-grade soil having low CBR values. The state governments may not be able to provide necessary funds for maintenance of rural bituminous roads due to inadequate funds available for maintenance of roads due to paucity of funds, which will result in loss of assets to the nation. Besides this, concrete roads once constructed properly, will prove an asset to the nation.

5. ROLE OF INDUSTRIAL WASTES IN RURAL ROAD CONSTRUCTION

In recent years, applications of industrial wastes have been considered in road construction with great interest in many industrialized and developing countries. The use of these materials in road making is based on technical, socio-economic, and ecological criteria. The lack of traditional road materials and the protection of the environment make it imperative to investigate the possible use of waste materials carefully. Natural materials being exhaustible in nature, its quantity is declining gradually. Also, cost of extracting good quality of natural material is increasing. Concerned about this, the scientists are looking for alternative materials for road construction, and industrial wastes product is one such category. If these materials can be suitably utilized in road construction, the major pollution and disposal problems can be partly reduced. In the absence of other outlets, these solid wastes have occupied several acres of land around industrial plants throughout the country. Keeping in mind the need for bulk use of these solid wastes in India, it was thought expedient to test these materials and to develop specifications to enhance the use of these industrial wastes in road construction, in which higher economic returns may be possible. The possible use of these materials should be developed for construction of low-volume rural roads in different parts of our country. The necessary specifications should be formulated and attempts are to be made to maximize the use of solid wastes in different layers of the road pavement.

Extensive post-construction pavement performance studies need to be done for these waste materials for construction of low volume roads with two-fold benefits. It will help clear valuable land of huge dumps of wastes and also to preserve the natural reserves of aggregates, thus protecting the environment. Materials such as fly-ash from thermal power plants and other coal fired industries, blast furnace slag from steel industries, cement kiln dust from cement related industries, phospho-gypsum from phosphatic fertilizer industries, and many other solid wastes have already proved to be useful for road construction in many parts of the country. However, there are situations in many states where the prescribed standards are not available at normal leads resulting in longer haulage and higher costs. The tests and specifications, which are applicable for conventional materials, may be inappropriate for evaluation of non-conventional materials, such as industrial wastes. This is because the material properties such as particle size, grading and chemical structure, may differ substantially from those of the conventional materials. Thus for an appropriate assessment of these materials, new tests should be devised and new acceptability criteria need to be formed.

6. CONCLUSION

The use of new materials and technologies is not becoming popular in India mainly due to lack of awareness among the masses. Failure to win confidence in the field engineers by addressing their problems can be another reason, the third being non-availability of suitable standard equipments. In the light of the fact that efficacy of innovative products and technologies was established in several case studies taken under varied conditions, time is opportune to initiate the construction of successive technology demonstration projects. All technical and implementation processes should be meticulously documented which become handy in the dissemination process for exposing more field engineers to these products and technologies. The successful demo of these pilot projects also brings out the cost effectiveness and conservation of natural resources that may lead to environmental preservation in the long run.

REFERENCES

[1] Nunes. M. C. M., Bridges. M. G., and Dawson. A. R., “Assessment of Secondary Materials for Pavement Construction: Technical And Environmental Aspects,” Waste Management, Vol. 16, Nos 1-3, pp. 87-96, 1996.

[2] Khanna, S.K., and Justo, C.E.G., (1993), “Highway Engineering”, New Chand and Bros, 7th edition, New Delhi.

[3] JAIN, S. Design of Rigid and Flexible Pavements by Various Methods & Their Cost Analysis of Each Method, Samrat Ashok Technological Institute, VIDISHA, MP, 2013.

[4] Prasad, Bageshwar (2007), “Life Cycle Cost Analysis of Cement Concrete Roads Vs. Bituminous Roads”, Indian Highways, Vol.35, No.9.

[5] Report on “Demonstration Project using Soil-Cement – RENOLITH stabilization technique” by PWD Rajasthan, India.

[6] Slab Stabilization Guidelines for Concrete Pavements, Technical Bulletin 018P, American Concrete Pavement Association, Skokie, Illinois, 1994.

AUTHOR'S BIOGRAPHY

Achal Garg, is currently working as a Structural Engineer at Keppel Offshore & Marine Engineering, Mumbai. He has attained his Bachelor degree in Civil Engineering from University of Petroleum and Energy Studies, Dehradun. He has published 12 research papers in leading national & International Journals. He is also associated with Society of Petroleum Engineers, American Society of Civil Engineers, International Safety Quality Environment Management Association, and IGET, Pune.

Harinder Yadav, is currently a final year student of Civil Engineering at University of Petroleum and Energy Studies, Dehradun. He has published various research papers in leading national & International Journals. He is associated with Global Shapers Hub, Dehradun.