

# Natural Rubber Modified Bitumen For High Performance Roads



K.S. Gopalakrishnan

By K.S. Gopalakrishnan, Director (T&TC), Rubber Board

Roads form one of the essential basic infrastructure facility for the development of a country. In India it is estimated that over 33 lakh kilometers of roads exist of which only about 50% is surfaced. Among

the surfaced roads, about 95% is constituted by bituminous roads. Factors like increased traffic volume, higher vehicle loads, inherent drawback of bitumen, adverse weather conditions, increased cost of road construction materials and wages etc lead to the inferior quality and increase in the cost of construction of bituminous roads. Several studies suggest that the useful service life of bituminous roads in India is only 2-4 years.

Properties of bitumen are the key factors that affect the quality of bituminous roads and some of the inherent drawbacks of the bituminous roads like i) Susceptibility to temperature variations, ii) Fattening up during hot conditions, iii) Tendency to crack during Cold climate and iv) Lesser effective service life etc caused the Engineers and Scientists to look into alternative and improved methods of construction of roads. One of the options developed through research and commercial findings is the development of rubberised roads.

Various experiments and studies were conducted all over the world, regarding the use of additives to bitumen, to improve the properties and increase the life of the road surfacings. Of these, the use of rubber (both natural and synthetic) in different grades and forms is of much significance, as it provided better performance than conventional bitumen and this has led to the basis of rubberisation of roads. In the past few decades, research and commercial trials have been carried out in different countries for improving the properties of bitumen for road construction. In the 1950's the major modifiers used were crumb rubber or tyre powder; Natural Rubber and other additives. Later in 1970's and 1980's Plastics/Elastomers like Polyethylene (PE), Ethylene Vinyl Acetate (EVA), Synthetic rubber like Styrene Butadiene Rubber (SBR) and similar materials were used as bitumen

modifiers. In the 1990's use of special additives and high strength materials like synthetic rubbers/polymers were used for modifying the bituminous surfaces in special applications like Airports (to absorb the impact loads).

The Road development sector has achieved good progress in India and growth of Express highways with higher traffic density, speed of travel, Safety management systems etc has become a reality.. There has been a radical shift from the conventional road construction methods to modern construction management including new highly sophisticated machinery to improve the quality and to increase productivity. In tune with this, the use of Natural Rubber Modified Bitumen (NRMB) is also accepted by the road sector to improve the properties of the pavements.

## Development of Natural Rubber Modified Bitumen

Basically rubberised bitumen comprises of a bituminous compound into which rubber in suitable form and proportion is added. The modified Bitumen is then used in road construction. Evaluation of technical properties of rubberised bitumen established that the main effects of incorporation of rubber into bitumen are on the Viscosity, Strength and Elasticity and even small quantity of Natural Rubber markedly changes the properties. Viscosity is increased considerably, susceptibility to temperature reduced drastically and strength is improved immensely. Also the natural rubber modified bitumen has improved binding properties with aggregates.

Further to this development, different forms of Natural Rubber like preserved field latex, sheet rubber, powdered rubber, ground vulcanised rubber etc were tried for rubberisation and of these the best performance was observed with Natural rubber in latex form. However, in countries where natural rubber is not readily available or it is of scarce supply, synthetic polymers, crumb rubber, recycled rubber etc are used due to economic and other commercial reasons.

Rubber Board of India also conducted laboratory and commercial trials in the early 1970's to assess

**N**atural Rubber Modified Bitumen (NRMB) improves the properties of the pavements

the potential for the development of rubberised roads. Small stretches of roads were rubberised at different places. The first road was constructed using rubberised bitumen in 1974 at Vembayam near Trivandrum on the MC Road in Kerala State. Though it was successful, the potential behind this development was not popularised due to the reason that Natural Rubber was a high demand product at that time and promoting non-conventional uses of NR was not given much importance.

Moreover during the early periods of development of NRMB, the process of preparation of Rubberised bitumen was very crude and labour intensive and it was not properly controlled. The bitumen was heated to 140°C in open vessels and to the molten bitumen, calculated quantity of latex was added and homogenised. The rubberised bitumen thus obtained was used for road construction. Practical difficulties were observed during mixing of latex with bitumen and batch to batch variation in quality was observed.

In order to overcome this difficulty the Rubber Board in collaboration with M/s Kochi Refineries Limited, Kochi, and the Highway Research Station (HRS), Tamil Nadu, conducted joint research to develop a commercially viable technology. Based on this Natural Rubber Modified Bitumen (NRMB), a pre-mix of rubber with bitumen which can be directly used for road surfacing as in the conventional way was developed. In this process Natural Rubber in the form of latex is added to bitumen at the refinery itself and the product is marketed in bulk or in barrels. Later M/s Hindustan Colas Ltd, Mumbai, also commenced production of NRMB with production units in Mumbai, Delhi, Baroda, Chennai and Vysakh. Altogether the installed capacity for the production of NRMB is about 1,10,000 MT per annum with locational advantages for supply to different areas. Natural Rubber Modified Bitumen from centralized processing units/refinery is available in India. It is supplied hot at 125-175°C in insulated tankers and in mild steel barrels. About 35,000 MT of NRMB was consumed for the rubberisation of roads in different parts of the country during 2003-04. The concept of Rubberisation of roads for the improved performance of the roads has gained greater importance in the recent years by the concerted efforts made by the Rubber Board and other agencies like the Central Road Research Institute of India (CRRRI) New Delhi, the Highway Research Station, Chennai, M/s Kochi Refineries Ltd, Kochi, M/s Hindustan Colas Ltd, Mumbai etc.

## Natural Rubber - An ideal modifier for bitumen

The following properties of Natural Rubber in the latex form makes it an ideal material for use in Bitumen. Natural rubber is

1. Is compatible with bitumen.
2. Resists degradation at mixing temperature.
3. Produces coating viscosity at application temperature.
4. Maintains premium properties during storage, application and in service.
5. Is cost effective on a life cycle - cost basis.

The process of modifying the bitumen binder appeals to be a logical, practical and economical approach to meet the required performance under the heavy traffic, climatic conditions and to meet the durability requirements.

The major advantages of rubberised bitumen which lead to improve durability of bituminous roads are

1. Act as multigrade over wide temperature range. Improved resistance to cracking at low temperature and better resistance to fatting up or bleeding of bitumen under hot conditions.
2. Resist stripping in presence of moisture at aggregate bitumen interface due to better adhesion between surfaces. Ability of modified bitumen to hold stone chippings with higher adhesive property.
3. Resistance to ageing and hence increased service life.
4. Increased resistance to flow or deformation
5. Better skid resistance leading to safer roads.

The above properties increase the service life of rubberised roads in many cases to more than 100% when compared to conventional bituminous roads.

## Guidelines for the use of rubber modified bitumen

The Indian Road Congress has come out with tentative guidelines for the use of Rubber and Polymer modified bitumen in December 1999 vide Special Publication No- IRC SP 53. This was later revised in February 2002. Based on this Natural Rubber Modified Bitumen is available in three grades NRMB-120, NRMB-70 and NRMB-40 and each grade is recommended based on the guidelines specified in IRC SP 53.

At present there are 4 types of Rubberised/Polymer modified bitumen available in our country viz. PMB (Elastomeric & Plastomeric), Natural Rubber Modified Bitumen (NRMB), and Crumb Rubber Modified Bitumen (CRMB). The molecular interaction and chemical reaction of rubber with bitumen leads to improved properties and this largely depends on the fine dispersion of rubber/polymer in bitumen. Modified Bitumen is generally recommended for roads with heavy traffic and located in extreme climatic areas. The selection criteria for different grades of modified bitumen shall be based on atmospheric temperature and pavement temperature as given in table given



below.

The Ministry of Road Transport and Highways (MORTH) Government of India, vide order No-Rw/NH 34041/86/90-SR (Vol-II) dated 21.04.1999 has given guidelines and instructions for use of modified bitumen in Highways. Use of modified bitumen for wearing course was approved by the National Highway Authorities for their road projects. Also the World Bank and Asian Development Bank have approved the specifications for the use of modified bitumen for the National Highway Development Project (NHDP) which includes Golden Quadrilateral Project, North-South and East-West Corridor and Port development Road Projects.

bitumen there are some constraints for the proper use of the material.

Availability of modified bitumen on a regular basis is very much essential. Performance history and information are required for easy acceptance of material by designers/engineers. Guidance

- Consistent availability of the material (Modified bitumen).
- Technical details about the product and performance data.
- Being a new product, reluctance from consumers for change from the conventional materials.
- Proper Guidance assistance for new users.
- Competition from similar other products.

### Selection Criteria for PMB, NRMB and CRMB

Maximum Atmospheric Temperature ° C

Pavement Temp ° C	<35	35 to 45	>45
<10	PMB/NRMB-120 CRMB - 50	PMB/NRMB-70 CRMB-55	PMB/NRMB-70 CRMB - 55
10 to -10	PMB/NRMB-70 CRMB - 50	PMB/NRMB-70 CRMB - 55	PMB/NRMB-40 CRMB - 60
>10	PMB/NRMB-70 CRMB - 55	PMB/NRMB-70 CRMB - 55	PMB/NRMB-40 CRMB - 60

*PMB and Rubber Modified Bitumen (NRMB/CRMB) grades indicated does not mean equivalent performance in indicated climatic conditions of the location*

### Cost of Rubberisation

Reliable estimates based on the construction of roads by several institutions indicate that the additional cost involved for use of rubberised bitumen will be about 5-7% only. The increase in cost of rubberisation can be well compensated by the advantages accruing by the use of NRMB viz improved performance and increased service life and lower maintenance cost. A preliminary evaluation by Central Road Research Institute of India, New Delhi reveal that the cost for periodic maintenance of rubberised roads can be reduced by about 35% compared to that of ordinary bituminous roads, considering a design period of about 20 years life.

### Use of Natural Rubber Modified Bitumen - Current Status

Though the technical details are specified and regulations are made for the use of modified

and assistance are needed for new users. Lack of any of the above will result in the lesser usage of the material. Though it is proven by scientific and observational studies that the rubberised roads give improved service life than ordinary bituminous roads, one of the hurdles for extensive road rubberisation is the absence of scientific data on the performance of rubberised roads. To evolve this data, a joint project was initiated by the Central Road Research Institute (CRRI), New Delhi. And the Rubber Board for the performance evaluation study of the rubberised roads. The study commenced during April 2003 and first phase has already completed. The results of the preliminary performance study of the roads conducted by the Central Road Research Institute (CRRI), New Delhi, are very much promising.

### Promotional measures by Rubber Board

The Rubber Board has been promoting the rubberisation of roads by all means. Seminars and workshops were conducted and technical assistance was provided for popularisation of technology. During the year 1998, a scheme for providing financial assistance to local bodies by reimbursing the cost difference between NRMB and Ordinary bitumen was implemented.

Rubberisation of roads improves the performance, increases the service life and reduces annual maintenance cost of roads. On a long term perspective it is prudent to promote extensive rubberisation of roads in our country as it combines savings with safety.