An insight into rubberised roads

Roads can be considered as a cause for, and consequence of, civilization and transport plays a very vital role in the life of any community today. The development of roads can be traced to military exigencies and the invention of wheeled vehicles contributed for its speedy development. Though the Mesopotamians were reported to be the serious road builders in history, the Romans are considered to be the earlier scientific road builders. The Industrial Revolution gave a fillip to road construction in Europe. India has also made important contributions for the development of roads. Studies on the Indus Valley Civilization indicate that burned bricks cemented with bitumen were used for road building.

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With the introduction of automobiles and heavy vehicles, the requirements of roads began to change drastically. The then prevalent methods of road construction became insufficient to copy with the new development. Pavements are classified into two types namely the Rigid and the Flexible ones. While concrete roads come under the category of rigid roads, bituminous roads are classified as flexible pavements. For a long time, bituminous pavements were the common form of roads. Later on concrete pavements were introduced. Being costly, the concrete pavements began to be confined to limited areas. Of the above types of pavements, bituminous pavements form the lion's share.

In India, it is estimated that over 20 lakh kilometers of road exists of which around 48 percent is surfaced and the remaining unsurfaced. Among the surfaced roads, the bituminous pavements contributes to the maximum. Some of the drawbacks of bituminous roads like high susceptibility to temperature variations, tendency to crack, lesser effective service life etc caused engineers and scientists to look for alternative methods of road construction which ultimately led to the use of rubber in road building.

Development of Rubberised road

A survey on the use of rubber in bituminous pavements[1] indicates that the subject of current interest can be traced to 1844. As early as 1901, an asphalt-rubber paving company was set up in France. Between 1922 and 1924, liquid rubber, a mixture of ground rubber and fillers, and latex were tested for roads. In the United States earlier development works on rubberised roads were carried out in 1925. In the U.S, rubberised roads were laid on experimental basis in places such as Ohio, Virginia, Texas, Minnesota, New York, Connecticut, Georgia, Massachusettes and Washington D.C. A large number of trials were conducted by the Dutch in various parts of the Netherlands. Exhaustive investigations on rubberised roads were also made in England, Indonesia, Malaysia, Australia and New Zealand.

Technique of Rubberisation

Basically rubberised bitumen comprises of a bituminous compound into which rubber in a suitable form and proportion is incorporated using an appropriate technique. Rubberised bitumen is then used in pavings using conventional road building techniques. Following the incorporation and uniform distribution of rubber, bitumen undergoes radical changes in its properties depending to a large extent on the following aspects[2].

(1) Type and grade of rubber used

(2) Ratio of bitumen to rubber and

(3) Method of incorporation of rubber into bitumen.

It has been clearly established that for maximum effectiveness, the rubber must dissolve in the binder (bitumen). When

properly incorporated, rubber increases the viscosity, strength and heat resistance of the system.

What happens on mixing rubber with bitumen

Prior to 1950s, the popular belief was that upon addition of rubber into bitumen, the rubber remained as discrete particles which absorbed some of the oily constituents from the bitumen thus making it harder, but also making it durable as the oily fraction was subsequently not lost so readily during atmospheric weathering. Laboratory studies conducted in early 1950s made it clear that when rubber is added into hot bitumen, it exists in the bitumen at first as a dispersion of fine particles. At this stage its contribution to the mechanical properties of bitumen is not much. On heating, the rubber particles swell and finally disperse to give a tough rubbery material. In this condition the rubber is able to change the mechanical properties of bitumen considerably. Being an unsaturated hydrocarbon, rubber gets degraded on prolonged heating at high temperatures and then its effectiveness is greatly reduced.

Laboratory Tests

Even though laboratory tests will not correctly indicate the road wearing characteristics, they reveal the following aspects.

(1) Changes in the properties of bitumen resulting from incorporation of rubber and how these can influence the service performance.

(2) Effect of the type, amount and method of incorporation of rubber on the properties of bitumen.

(3) Commercial procedures for the production and laying of road binders.

Laboratory studies conducted have established that the main effects of incorporation of rubber into bitumen are on the viscosity, strength and elasticity[3] of the latter. Even small quantities of rubber markedly change the above properties: viscosity is increased considerably, susceptibillty to temperature is reduced drastically and strength is improved immensely.

When rubberised bitumen is used in constructing pavements, the following advantages are expected to materialise

(1) Improved resistance to cracking.

(2) Better resistance to fatting up.

(3) Improved resistance to deformation or flow.

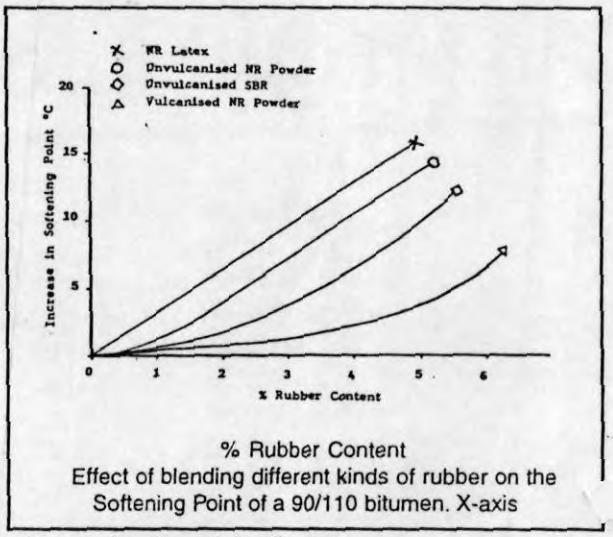
(4) Higher stability

(5) More resistance to stripping

The above indicates that the performance of rubberised bituminous pavements can be definitely superior to the conventional bituminous roads. However, actual full scale trials are the only way to ascertain the cost benefit aspects of the rubberised roads.

Which rubber to use?

Smith Li M. had conducted a comprehensive series of trials to ascertain the relative effectiveness of different rubbers in altering the properties of bitumen.[4] His trials have indicated that the simultaneous changes in viscosity, elasticity and a brittleness taking place on incorporation of rubber into bitumen are linearly related to the softening point as given below:



% Rubber Content
Effect of blending different kinds of rubber on the Softening Point of a 90/110 bitumen. X-axis

Determination of the Softening Point thus provides an easy way for assesing the effectiveness of different kinds of rubbers. The results shown by Smith indicate that the increase is maximum when the rubber is dissolved in bitumen and that Natural Rubber (NR) in latex form is the most effective one followed by unvulcanised NR, unvulcanised Styrene Butadiene Rubber (SBR) and vulcanised NR.

Blending times for unvulcanised and vulcanised NR with Asphalt

The Road Research Laboratory, London had carried out investigations on the factors affecting incorporation of NR into Asphalt. Effect of blending time on temperature of mixing has been reported as under.[5]

Blending time for NR with Asphalt

Blending Temperature °C	Blending time (minutes) Unvulcanised NR	Vulcanised NR
140	25	360-480
150	15	180-240
160	10	120

NR is an unsaturated polymer which will be degraded on prolonged heating, especially at high temperatures. The mechanical properties of degraded rubber are poor. As such the effect of time and temperature of heating when NR is added into bitumen is very much important. The following results are from the studies conducted by the Road Research Lab, London.

Effective rubber/Total standard rubber

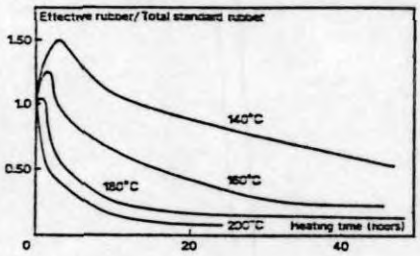


Fig. 2 - Change in effectiveness of rubber latex in asphalt during prolonged heating.

Effective rubber content was determined by the increase in the viscosity produced by the rubber. It can be seen from the above that the effectiveness of rubber increases at first and then decreases as heating time is prolonged. The above results indicate that rubberised asphalt should not be stored at higher temperatures for longer duration Allowable storage times for rubberised asphalt at different temperature are as given below[5].

Since the chemistry and technology of bituminous road binders and rubbers are very much different, it is imperative that for getting desired results from the use of rubberised bituminous materials for road surf acings, a proper interaction of the experts in both the disciplines is a must. In many countries full scale paving experiments were carried out by the combined efforts of Road Research Laboratories and Rubber Bureaus. The types of surfacings investigated were:

1) Seal coat (surface dressings) 2) Rolled asphalt 3) Mastic asphalt 4) Asphalt Macadam.

The full scale paving experiments were intended for assessing:

1) Ability of rubberised bitumen to hold stone chip pings in comparison with ordinary bitumen.

2) Susceptibility of rubberised bitumen and ordinary bitumen to withstand wide temperature variations usually experienced.

3) Cost effectiveness of rubberisation.

The results of several carefully desired full scale road experiments conducted in many parts of the world clearly indicate that proper incorporation of adequate quantity of natural rubber in appropriate form into bitumen and use of such rubberised bitumen in pavings will undoubtedly lead to Saving and Safety'.

Allowable storage time for rubberised asphalt

Temperature°C	Storage time (hrs)
Normal room Temperatures	Indefinitely
130	72
140	48
150	18
160	12
170	4
180	3

Fullscale paving experiments on rubberised asphalt

Cost of Rubberisation

Estimates prepared by the Natural Rubber Producers Research Association in 1971 show that 12 to 15% additional cost will have to be incurred for seal coats using 2% rubber and 16% additional cost for rolled asphalt at 4% rubber. Experiments conducted by the Rubber Research Institute of India show that additional cost involved for the normal type of road surfacing usually adopted in Kerala would be about 16%, with 2% rubber. 13 KMs. of road on the way to Sabarimalai (a pilgrim centre) have been recently rubberised (with the active involvement of the public in that area) incorporating 2% rubber on the weight of bitumen and the additional cost incurred was about 17%.

The additional cost of rubberisation (15 to 20%) will be more than compensated by the advantages accruing by the use of natural rubber.

Future of rubberised roads under Indian conditions

Results of laboratory experiments as well as full scale road trials have clearly established the superiority of natural rubber modified bitumen in pavings compared to ordinary bitumen as far as savings and safety factors are concerned. Natural rubber is produced in adequate quantity in India and available at reasonable price. In a developing country like India optimum utilisation of resources available in the country deserves prime consideration. The authorities concerned with road construction at the State and National levels may take appropriate measures for the extensive rubberisation of roads. To begin with, it is suggested that one Kilometer road may be rubberised in every Municipality and 5 Kilometers in every Corporation. State PWDs may undertake rubberisation of 100 KM stretch road in every State and the National Highways Department 200 Kms. The results from such trials will be enough to undoubtedly convince the decision making machinery about the long term advantages of rubberised roads and to go in for rubberisation of roads in a big way.