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Rubber in Bituminous Mixtures

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Rubber in Bituminous Mixtures

1. Chuzo Itakura, Teruo Sugawara, Some Characteristics of Rubber-Blended Asphalt and Its Mixtures at Low Temperatures. Proc. of AAPT, Vol 28, 1959, pp. 385-412.

The present paper is divided into two series of researches, one on asphalt mixture blended with natural rubber powder, and another on those blended with two kinds of reclaimed rubber besides the natural rubber powder. On those two series, different kinds of asphalt were used, so that tests results did not coincide in detail, but the main points were generally reached. This lack of coincidence may depend upon source of asphalt and interesting problems are left for future researches. In these researches remarkable changes of physical characteristics of rubber blended asphalt were revealed, and it may be said that rubber powders act not only as filler but also as a chemical additive.

2. Walter F. Winters, Barytes in Rubber-Asphalt Mixtures, AAPT Proc., Vol. 25, 1956, pp. 379-391.

The field of rubberized asphalts in highway use has been steadily progressing in the past several years. As with any relatively new process, improvements and changes can be expected from time to time, however, the fact seems to be established that rubberizing an asphalt is advantageous provided correct techniques are employed in dispersing the rubber. It also follows that the proper rubber should be selected to provide the improvement that is desired. Barytes-rubber is a step in the right direction. It has the aspects of being a very practical rubber additive that is thorough and efficient in its function. It contains Butadien Styrene rubber which provides the greatest beneficial changes and barytes which supplies characteristics, all of which are needed for the production of a premium type of asphalt.

3. L. E. Gregg, W. H. Alcoke, Investigations of Rubber Additives in Asphalt Paving Mixtures, AAPT Proc., Vol 23, 1954, pp. 28-63.

Asphalt-rubber combinations in which the rubber was highly dispersed were accomplished through the introduction of rubber in latex or liquid form. The manner and degree of dispersion varied with different combinations and conditions of the time the additives were introduced. No feasible method of measuring degree of dispersion was developed, but various dispersions observed in microscopic studies made with the different materials were correlated in general with tests for flexure-fatigue.

The flexure-fatigue test, developed specifically for this investigation, measured pronounced differences among sheet asphalt mixes made with the different asphalts and asphalt-rubber binders. Through tests on compacted specimens artificially aged in an oven for increasing periods of time, decreased resistance of the mixes to flexure fatigue could be expressed as functions of the period of oven exposure.

Some physical properties of the asphalts and asphalt-rubber mixes were evaluated by termperature-penetration and temperature-viscosity relationships supplemented both by observations of microscopic slides indicating structure, and by demonstrations indicating toughness or ability to absorb the energy of applied loads without failure. Selective solubility and partition chromatography were applied to the determination of asphalt components, principally from the standpoint of the accuracy of methods involved. As means for determining the placability of mixes containing asphalt rubber combinations exhibiting a high degree of tenacity, one of the latex additives was introduced in the full-scale mixing of bituminous concrete placed on a highway by normal paving operations.

Results of the various measurements and observations show that at least some types and forms of rubber additions to asphalts producd increased toughness or capacity for energy absorption, and also decreased temperature susceptibility expressed most clearly as increased viscosity at high temperatures and decreased viscosity at low temperatures. The exact physical properties of rubberized binders and flexure-fatigue resistance of mixes made with those binders vary with the type of rubber, the source and production of asphalt, dispersion of rubber, and the microstructure formed by the rubber in the asphalt. The most desirable properties are achieved with a high degree of dispersion and a random fibrous structure within the asphalt which is reflected by a similar but coarser structure of fibers within the paving mix.

Definite boundaries between components in asphalts are not established by the usual procedures of separation through selective solubilities. Chromatographic partitioning is definite in establishing the boundaries qualitatively, and it shows promise of becoming equally effective for quantitative measures. In addition, improvement is known analytical procedures may be effected though the use of chromatography for evaluating the purity of fractions separated with different solvents. Chromatographic analysis in this work favors the concept of four discrete fractions in asphalts, with two representing transitions between the oils and asphaltenes.

Introduction of additives in latex forms is feasible with the rubber as either an ingredient premixed with the asphalt or an admixture to asphalt and aggregate at the time of preparation of paving mixes. Within the limitations of materials investigated, the results were better with the rubber introduced as an admixture rather than as an addition, probably because of the random distribution and structure thus achieved. Despite the tenacity characteristic of effective asphalt-rubber combinations, placability of paving mixes is not appreciably impaired by the rubber additive.

4. Production of Powdered Rubber, Malaya, Foreign Commerce Weekly, Vol. XXXVIII, No. 10, March 6, 1950. Highway Research Abstracts, Sept. 1950.

The Director of Malayan Rubber Research Institute, in a recent press release, stated that the Institution was working on the preparation of special rubbers, including rubber powders, as part of its 5-year research program. He stated that negotiations were under way with the Dutch Government for permission to manufacture the powdered rubber, "Mealorub," first made by the Dutch and used in rubber-roads trials in the United States.

Under an agreement among British, Dutch, and French producers, the field for research and development of new uses for rubber has been apportioned in the three countries in order to avoid waste of effort.

The Director of the Rubber Research Institute, on receiving estimates from the United States placing the demand for road surfacing rubber at 100,000 to 200,000 tons annually within 5 years, was quite optimistic although cautions in accepting the full implications. If such a demand develops, every effort will be made to expand production.

A plant capable of producing 50 tons of powdered rubber a month with a potential of several times that amount if the demand so warrants, is being built at Singapore. The managing director stated that full commercial production would commence soon. He also stated that the only other place where powdered rubber is being produced is the pilot experimental station at Buitenzorg in Indonesia. A larger plant is reportedly being built on a Goverment estate in Indonesia.

5. Traces History of Synthetic Rubber, Canadaan Section. A. H. Glionna, Field Editor, SAE Journal, Vol. 58, No. 12, December 1950. Highway Research Abstracts, February, 1951.

"I predict that use of chemical rubbers will expand greatly during the next few years, and that the decade 1950-1960 will see world consumption of new rubber above two million tons per year," said E. R. Rowzee in his talk "Synthetic Rubber Comes of Age."

The manager of Polymer Corp., Ltd., Sarnia, Ontario, traced the history of synthetic rubber back to fundamental research in Britain in the 1880's which led to its discovery. Key developments in growth of the industry, he said, were discovery that isoprene could be polymerized to form a synthetic rubber; production of neoprene by duPont in the 1920's; wartime development of German buna rubbers and GR-S; and Butly discoveries by United States and Canada during the same period.

The speaker gave the following reasons for his confidence in the firm position of the synthetic rubber industry; eight years experience with the product have given consumers a working knowledge of its advantages and weaknesses; "synthetic rubbers have improved markedly during the past several years and ... will continue to improve; it's certain that synthetic rubber has achieved a degree of price stability which natural rubber cannot hope to match."

6. Rubberized Bitumen as Spray Coat, Highways and Bridges and Engineering Works, Vol. XVIII. No. 893, (England) August 15, 1961. Highway Research Abstracts, October, 1951.

The City of Leeds Highway Department, in association with Crowley, Russell & Co., Ltd., of Castleford, Yorks, has just completed resurfacing over one mile of main trunk roadway with a dressing of chippings and bitumen containing rubber.

The material used was a 60-70 penetration bitumen to which approximately 2 percent of rubber powder was added. This had been heated with a constant agitation for approximately three hours at a temperature of 300 F., after which a light creosote oil was added was a flux. The spraying bitumen was delivered to the site from Crowley Russell's plant at Castleford in insulated road tanks at a viscosity of 300-320 secs., standard tar viscometer, and was applied at a temperature of 280-300 F. The handling and application of the rubber-bitumen to the site was exactly the same as would have been occasioned by the use of normal bitumen.

The work was carried out with a Johnston rotary-brush sprayer at a cover of 5-6 sq. yd. to the gallon, used in conjunction with a gritting machine using 3.4 in. whinstone chippings at approximately 70-80 sq. yd. per ton. The consolidation of the surface was by means of 10/12 ton rollers.

7. The Use of Rubber in Bitumen for Road Surfacing, Engineering, Vol. 172, No. 4466, August 13, 1951, (London) Highway Research Abstract November, 1951.

Since the end of the second world war, rubber-asphalt materials have come into greater prominency as a result of work carried out not only in Great Britain, but also in other countries; Dutch and Indonesian scientist, for example, were largely responsible for developing methods of producing rubber in particle form and showing that, in this form it can be mixed with asphalt and bitumen. A trial section of powdered rubber asphalt road surface was laid at Leeds, where in 1950, the Cith Corporation Highways Department commissioned the surface dressing of a stretch of the Leeds-Selby road, the dressing consisting of rubber-bitumen sprayed on to the existing surface and coated with 3/4 in. whinstone chippings.

Results obtained from this experimental section indicated that rubber-bitumen spraying is superior to ordinary bitumen spraying, particularly with regard to adhesion of the aggregate to the road surface.

Further experiments will probably indicate also whether the introduction of rubber necessitated changes in the bitumen or aggregate content of existing specifications.

8. Experimental Work on Rubberized Asphalt Surfacings, Commonwealth Engineer, Sept 1, 1951. Highway Research Abstracts, Feb. 1952.

An interim report has been issued on the condition of an experimental rubberized asphalt road laid down in Singapore in May, 1950. The tests have so far given the following information:

(1) The paving laid in Sections 2 and 6, prepared by adding the rubber powder direct to the hot bitumen and hot aggregate respectively, is still deficient in stability 12 months after the time of laying.

(2) The increase in specific gravity and the decrease in water absorption in both the above sections indicate the mixtures have consolidated to a more satisfactory compaction through the passage of traffic.

(3) The paving laid in Section 1 and 5, where the rubber powder and the bitumen were heated for 3 hrs. at 330 F before being mixed with the aggregate, shows satisfactory results in all three tests.

(4) The paving laid in Sections 3 and 4, containing rubber in the form of latex, is satisfactory. The small variation in the specific gravity of these samples indicates that the paving attained full compaction almost as soon as it was laid.

(5) The increase in the stability value of the mixture in the control section which contained no rubber powder is very much greater than the increase in the stability value of any of the rubberized mixtures.

Although no conclusive results have been obtained, the indications are that the rubberized asphalt surfacing is more nonskid than the plain asphalt surfacing.

9. Estimation of Rubber in Asphalt, Geert Salomon, Elizabeth Pezarro-Van Brussel and Abraham C. Van Den Schee. Analytical Chemistry, Vol. 26, No. 8, pp 1325-1328, August 1954. Highway Research Abstracts October 1954.

As a corrollary to the growing tendency to add elastomers to bitumen and asphalt, a method by which these polymers can be estimated quantitatively in mixtures is needed. The method of van Heurn and Begheyn has been adapted to a problem of current interest. By prolonged extraction with xylene or higher boiling solvents, raw or vulcanized natural or synthetic rubbers are separated from the stone chippings in asphalt. The rubber in this soluble fraction then reacts with a large quantity of sulfur and the rubber content is determined from a sulfur analysis of the parified ebonite.

The influence of reaction time and temperature, the type of rubber and bitumen, and the viscosity of the mixture on the experimental error has been specified. Determination can be made of 2 to 10 percent of a previously unidentified natural or synthetic rubber in asphalt and bitumen mixtures. The result is generally 10 to 20 percent higher than the true value. If the mixture has been heated above 265 C. prior to analysis, most of the rubber is irretrievably lost, but this pretreatment is revealed by a simultaneous hardening of the bitumen.

10. Rubber Crossing Smooths Ride, Materials and Methods (Reinhold Publishing Co., 330 West 42nd Street, New York, N. Y.), Vol. 43, pp. 262, 264, March 1956. Highway Research Abstract, May 1956.

Motorists on US 42 near West Salem,Ohio on crossing the Erie Railroad tracks will see the first rubber highway railroad crossing, recently installed by the Erie Railroad. The new vehicluar roadway consists of slabs of rubber with embedded seven-gage steel supporting members. Slabs are bolted through the railroad tie shims to regular roadbed ties. Provided with tapered flanges, the rubber slabs are designed to make a watertight seal with the rails.

Route 42 at this point is one of the most heavily traveled in the United States with the crossing battered around the clock by a constant stream of cars, trucks, and trains. The new rubber crossing is resilient to vibration from trains and motor vehicles and won't "float" or break up under the pounding.

In tests last year an experimental crossing was constructed on the Erie line in Akron. After a winter and summer of use, the rubber slabs showed no apparent wear or deterioration. Based upon this experience, Erie Railroad officials expect the rubber crossing to reduce maintenance costs drastically.

Public relations-wise, the rubber roadway provides a smooth, cushioned ride for the motorist and should eliminate the special irritation usually reserved for railroad crossings by car owners.

11. Rubber-Latex-Cement Compositions, P. B. Cormac. Rubber Developments (England), Vol 8, No. 2, pp. 46-52. Summer 1955. Highway Research Abstracts, September 1955.

The most-important advance in recent years has been the perfecting of a practicable method by which rubber latex can be combined with cement of the portland type. The problem was to find a means of ensuring protection of the latex against spontaneous coagulation on addition of the portland cement, stability of the mixture against unworkably rapid setting and sufficient speed of hardening to avoid shrinkage cracks.

Various techniques for the stabilization of rubber latex were tried unsuccessfully. A simple, logical but highly fefective treatment of the cement during the blending with aggregates was developed which overcame the difficulty. It was found possible to obtain a latex-cement compound which remained in the plastic state for a period sufficiently long to allow comfortable application, yet at the same time, hardened so rapidly that in many circumstances, it could be put into use within 8 hours.

Time has also tended to confirm that although various natural rubber latices have been used for the formulation of latex-cement compounds a "whole"latex, concentrated by evaporation, is more generally suited to this type of work. Particularly noticeable is the superior resistance to atmospheric ageing that results from its use.

Until recently the application of rubber-cement mixtures has been almost entirely by means of annual trowelling with a steel float. This has meant that application to large areas, such as sea defence works, coal bunkers, etc., and to complicated structures where girders, bracings, cleats, rivet heads, etc., are involved was either impracticable or uneconomical.

Considerable time has been devoted to investigating alternative methods of application in situ, and a special spray gun has been developed and an operating technique perfected. Extensive areas and complicated sections can be covered rapidly. In addition, due to the velocity at which contact with the surface is made, maximum bond is obtained and the applied product possesses increased tensile strength and impermeability.

In some cases it is appropriate to utilize latex-cement coating materials in prefabricated form, such as sheeting, tiles or as a facing for concrete blocks, piles, tubes, etc.

It has been found that coatings of these mixtures can be completely integrated with concrete units during the casting either under vibration or by spinning.

There is an ever-widening scope for the use of latex-cement compositions in this field, particularly in corrosion-resistant construction. The function of such coatings and linings is to protect plant and structures from the destructive effects of chemical attack or mechanical wear and more often than not, a combination of the two.

Latex-cement compounds will therefore be found as linings or coatings in bridges, pipe lines, and sea-defence works.

Perhaps the most-significant fact that the emerged from marine trials is that not only have latex-cement compositions, particularly those based on a whole latex, an extremely good resistance to weathering in marine atmospheres, but also that prolonged immersion in sea waters confers a decided toughening effect on the film structure. Moreover, alternate wetting and drying and exposure to sunlight do not appear to lessen this effect.

From a study of the problem of sea defence, it seemed that if some element of resiliency could be imparted to concrete structures employed for this purpose, the effects of wave and beach action could be appreciably reduced. Latex-cement coatings suggested the means. In conjunction with the various authorities concerned with sea defence on the south coast of England several test areas were installed over 5 years ago. The materials were applied in various forms: by gunning direct on to an existing and eroded sea wall, as a facing to concrete wall blocks and piles by integration during casting, and as a mortar for joining granite sets in the forming of a conventional wall block. It was also installed as a pointing in an existing wall where the mortar between the granite cubes had been badly eroded.

From recent examinations of these installations, it was established conclusively that the coatings and joints had provided a considerable measure of protection to the concrete. In the case of the precast units, the depth of wear of the latex-cement mixture was immeasurably small.

12. Rubberized Bituminous Materials and Their Use in Road Construction W. D. Parker and W.D.C. Walker. Journal of Applied Chemistry (Society of Chemical Industry, 14 Belgrave Sq., London, S. W. 1) Vol. 7, Pt 9, pp. 481-491. Sept. 1957.

The compatability of natural and synthetic rubbers and polymers such as polyvinyl chloride with coal tar pitches and bitumens is described. The penetration/softening point and penetration/temperature characteristics of a range of modified compositions are examined in relation to those of residual and blown bitumens and of coal tar pitches. A test has been devised for assessing the brittleness of bituminous materials and this is compared with the penetration, ductility and Fraas brittle point tests. Suggestions are made as to how modified tars and bitumens may be used in road construction, with particular reference to the use of tars with reduced temperature susceptibility.

13. NaturalkRubber for Roads, Surveyor (42 Russel Sq., London, W. C. 1), Vol. 117, No. 3475, p. 1163, November 29, 1958.

The laboratory and full-scale research on the use of rubber in road surfaces undertaken by the Road Research Laboratory in collaboration with the British Rubber Producers" Research Association and the Natural Rubber Development Board, is described in "Natural Rubber for Roads - A Review of Research and Experiment" (Rubber in Road Engineering, Technical Note No. 3), recently published by the Natural Rubber Development Board, Market Buildings, Mark Lane, E. C. 3.

Features of this work-which still continues--are investigations into the effect of rubber on the viscosity and low temperature extensibility of bitumens and sand asphalts; penetration, softening point and brittleness tests; and assessment of rubberized bitumen binders. The recommended blending conditions for the three powders at present commercially available are set out in tabular form, and methods of preparing rubberized bitumen and rubberized plant mixed carpet materials are discussed. Finally, there is a description of work done on rubberized tar and of the full-scale surface dressings laid in September 1957, with this type of binder.

14. Some Viscous and Elastic Properties of Rubberized Bitumens. L. M. Smith Journal of Applied Chemistry (Society of Chemical Industry, 14 Belgrave Sq., London, S. W. 1), Vol. 10, Pt. 7, pp. 296-305, July 1960.

The simultaneous changes in the viscous, elastic, and brittle properties that result from the addition of rubber to bitumen have been investigated for several different types of rubber and bitumens ranging in hardness from 170 penetration to 55 penetration. The results show that the changes in viscosity and low-temperature extensibility are due, in the main, to the molecular (or near molecular) dispersion of rubber in the bitumen. For a given bitumen these changes are linearly related both to each other and also to changes in softening point, thus giving a simple method of assessing the relative merits of different types of rubber. It is shown that sulphur added to latex or present in a vulcanized rubber causes a rapid breakdown of the rubber when it is heated with bitumen. An equi-viscous basis is suggested for the characterization of rubberized bitumens.

15. The Effects of Natural Rubber on Road Binders and Their Contribution to Improvements in Road Surfaces. P. D. Thompson. Road International (1023 Washington Bldg., Washington, D.C. 20005) No. 55, pp. 30-38, Dec. 1964.

The addition of a few percent of natural rubber produces marked changes in the physical properties of bituminous road binders. Pronounced elasticity, reduced temperatures susceptibility, marked deviation from Newtonian flow and increased resistance to fracture under impact are the main changes. The extent of these changes depends on the form in which the rubber is used. Recently, methods of analysis have been developed by which the effectiveness of the rubber, which is related to its chemical state, can be assessed. These methods have been used to give an estimate of the time allowable for storage of rubberized materials at elevated temperatures, since the state of the rubber is affected by severe heating.

Full-scale experiments carried out by the Road Research Laboratory in the United Kingdom in cooperation with the Natural Rubber Producer's Research Association have shown definite advantages for the use of natural rubber blended into the binder of mastic asphalt, rolled asphalt, bitumen macadam and surface dressing.

16. Full-Scale Road Experiments Using Rubberized Surfacing Materials, 1953-63. P. D. Thompson. Gt. Brit. Road Research Laboratory (Her Majesty's Stationery Office, London), Road Res. Tech. Paper 71, 1964, 24 pp.

Review of the results of a number of full-scale road experiments using rubberized surfacing materials indicates that advantages can be obtained from the addition of rubber. The addition of rubber to mastic asphalt has prevented or markedly reduced cracking when a bituminous surfacing is laid over joints or cracks in a concrete base. The addition of 10 percent rubber to the binder of rolled asphalt has considerably reduced the number and severity of cracks in this surfacing materials laid over joints and cracks in a concrete base.

A substantially increased life has been obtained when 4 percent rubber in powder form was added to the binder of bitumen macadam. Only one experiment has so far been carried out on this material and a further experiment has been started to observe the behavior of open-textured carpets to which rubber has been added in the form of latex. A limited full-scale experiment has suggested that the life of dense tar surfacing may possibly be increased by the addition of rubber powder to the binder. In one surface-dressing experiment, a commercially available rubber-tar showed no improvement over normal tar. Interim results of a second experiment suggest that some advantage may be gained by the use of a graft-rubber-tar in tar surface dressing. A considerable reduction in the tendency of bitumen of surface dressings to 'fat up' in hot weather under traffic has been shown when rubber has been blended with the binder. An increased initial holding power of the binders containing rubber has been observed.

17. Rubberized Asphalt, Jewell R. Benson (Letter to Editor) Western Constr. (King Publications, 709 Mission St., San Francisco 5, Calif.) Vol. 34, No. 7, p. 68, July 1959.

The Colorado Highway Department began use of rubberized asphalts for surface treatments in September, 1954, with installations at Rifle and near Alamosa. The success of these projects (determined after 2 yr of observation) led to extensive use of rubberized asphalts for this purpose of that department.

Initial work in Colorado, and through 1957, was primarily with asphalt rubberized with 3 percent butadiene-styrene type 2006 polymer, this material giving excellent results. However, in 1958, several cars of asphalt (in RC-3 and RC-4 grade) were used, rubberized with Neoprene type 635 latex, using 1½ percent rubber in the base asphalt. The handling and behavior of the Neoprene rubberized asphalt has led the department to almost exclusive use of this type of rubber this season, with only 1 car of butadiene-styrene rubber to be used.

It is the opinion of the engineers associated with the work that the Neoprene rubberized asphalts develop high degrees of aggregates holding-power more quickly than the butadiene-styrene rubberized materials, although the latter are many times more superior to untreated asphalts.

The purpose of the experimental projects at Walsenburg, Colo., was to determine the relative behavior of the butadiene-styrene and Neoprene rubberized asphalts, compared to asphalt rubberized with natural rubber, and to untreated asphalt. The natural rubber RC-3 was the first to be made by the Benson Process, and an unexpected gelling reaction occurred during application, giving high viscosities and a poor application in 2 of the 3 tests sections allotted to each asphaltic material. (Cause of the gelling was determined, and should natural rubber be used in the future, no difficulty from this source is expected.)

In this test, the same application temperatures (except in the gelled natural rubber), application rates and application rates of aggregate were followed for all materials. Within a few days after construction, all control sections, using a straight RC-3, had darkened perceptibly, while all rubberized sections remained free from darkening, bleeding or excessive loss of aggregate. Nine months after construction, these differences in appearance remain.

With the behavior of the various asphaltic materials determined for the initial 9-mo period, the project is now of special interest in long-time behavior, extending over a period of years. It is hoped that significant differences in behavior of the different rubber materials will develop, permitting a better evaluation of the type of rubber to be used in future work.

18. "Rubber" Base Mortar Undergoing Tests, Michigan Roads and Construction, (P. O. Box 780, 302 Hollister Bldg., Lansing 3, Michigan), Vol 56, p. 9, April 9, 1959.

State Highway Department researchers are quietly optimistic about a new "rubber" base latex mortar now being tested which may solve the old problem of thin-patching structural concrete.

A rubber derivative, liquid latex emulsion is added to concrete during the regular mixing process, which then results in a more pliable, chemical resistant finished product.

Because of the latex mortar's pliable nature, it permits patchwork at a minimum thickness of half an inch. Normal patching operations consisted of removing a large portion of the original concrete, generally to a depth of 4 in., to assure an adequate bond with the concrete base.

The latex mortar patch, because of its greater ability to bond with the original concrete and its greater pliability, tends to conform to the contracting-expanding cycle of the original concrete, thereby reducing stress on the patch.

In its first rigorous field test, the latex mortar was used in the fall of 1957 to patch a disintegrating, heavily-traveled bridge deck on a bascule bridge at Cheboygan. A minimum of half an inch of deteriorating concrete was removed and replaced with an equal amount of latex mortar.

A year later, after approximately 100 freeze-thaw cycles, the patch was examined for loss of bond and durability and was judged "very satisfactory." Other experimental latex mortar patching preparations used on the same bridge deck failed in varying degree.

Laboratory tests on the experimental latex mortar indicate that it has increased resistance to salt action, a lower water-cement ratio with increased compressive, tensile and flexural strengths, and a reduced water absorption, resulting in a greater concrete strength.

19. Field Experiments with Powdered Rubber in Bituminous Road Construction, Tilton E. Shelburne, Director of Research, Virginia Department of Highways, and R. L. Sheppe, Associate Research Engineer, Virginia Department of Highways, Highway Research Board Bulletin No. 27, 1950, pp. 13-24.

Information concerning foreign experiments with rubber in bituminous road surfaces indicates that such combinations may have merit. It is claimed that the addition of small percentages or rubber results in a more durable mixture - one that is less susceptible to temperature change, thereby having less tendency to bleed or shove at high temperatures or to crack at low temperatures. Resistance to skidding is said to be improved.

This report describes three field experiments with powdered rubber built during the summer of 1949 by the Virginia Department of Highways on Route 250 west of Richmond. In Section 1 powdered natural rubber was incorporated in the bituminous concrete sand asphalt wearing surface. Section 2 was a similar surface to which reclaimed powdered rubber was added. The third section was a seal treatment with cut-back asphalt (RC-2) to which natural rubber was added. The third section was a seal treatment with cut-back asphalt (RC-2) to which natural powdered rubber was added and mixed in the distributor prior to application. Identical sections (I-C, 2-C, and 3-C) without rubber were constructed adjacent to the experimental ones for purposes of comparison. Sections 1 and 1-C were constructed in May, 1949, and the remaining ones in September 1949.

Complete records were secured at the time of construction concerning materials, quantities, procedures, temperatures, workability, etc. Following studies since construction included visual observations road roughness measurements, and skid tests. Since Section 1 and 1-C were constructed earlier, more data are available on their performance, particularly as related to skid resistance.

At this time little, if any, difference can be noted between comparable sections with and without rubber. Road roughness measurements made on Sections 1 and 1-C shortly after construction indicated no significant differences between the two sections that could be attributed to the use of rubber. In both sections, however, the outside lanes which carry the majority of traffic were considerably rougher than the inside of passing lane.

Two series of skid tests have been conducted on Sections 1 and 1-C - one immediately after construction (May 1949) and the other six months later (November, 1949). Only one test series has been performed on the remaining sections. These were made on November, 1949.

Resistance of the surface to skidding was determined by the stopping distance method. All surfaces including the control sections were found to have satisfactory resistance to skidding, both in a dry and in a wet condition. Stopping distances on Section 2, containing reclaimed rubber, were practically identical with those on the control section (2-C). The seal treatment (Section 3), including natural powdered rubber, indicated a slight beneficial effect since the stopping distance on the wet surfaces at 40 mph. was about 3 ft. shorter than on Section 3-C. It is possible that slight surface texture variations may at least partially account for the difference. Additional tests at later dates will have to be made for further evaluations.

20. A Cheaper Rubber-Bitumen Using Latex, P. D. Thompson. Rubber Developments (Natural Rubber Bureau, 1108 16th St., N. W., Washington 6, D. C.) Vol 14, No. 2, pp. 61-64, 1961.

The method described results in a more effective use of rubber without the disadvantage of foaming associated with the use of latex.

It is undoubtedly true that, of the rubber additives normally used, natural rubber added to bitumen in the form of latex results in the greatest improvement in properties. Moreover, latex is cheaper than most other forms of rubber additive.

The methods of blending bitumen with latex have, until recently, been by the control and harnessing of foaming to play a part of the mixing process, as in the method patented by Benson in the United States, or by the use of anti-foaming agents. These agents are added in very small quantities and do not materially increase the cost. They reduce the foaming to manageable proportions but do not eliminate it completely. Recent research has resulted in the development of another method of blending for cutback bitumens which eliminates, almost entirely, this feature of latex addition.

A feature of the new method of latex addition is that the blending temperature is kept to below 120-130 C and the rubber remains in its most effective form. Thus, less rubber can be used and a further reduction in the price of the rubberized binder achieved.

The method depends essentially on the fine dispersion of latex in the blexing oil prior to mixing with the base bitumen at a temperature below which no immediate gelling will occur. Naturally, the concentration of rubber in the oil will be high--about 11 percent in a 100 sec cut-back with 2 percent of rubber on base bitumen. Further, on heating to expel the water, gelling will take palce at some stage. In the case of kerosene, gelling will take place less readily than in tar oils. Unfortunately, a ruberized flux oil of these proportions is inconvenient to handle and is very insensitive to temperature over a large range. Some bitumen is therefore added to the flux oil initially both to reduce the rubber content and to increase the temperature sensititity. The amount of bitumen added in this "maste batch" will depend on the type of mixing plant available for dispersing the rubber-flux oil in the bulk of the straight-run bitumen.

The estimated quantity of flux oil required to produce the final viscosity of the rubberized binder is mixed with an equal quantity of bitumen in a binder heater to which is fitted a propeller-type stirrer. The latex is added slowly at room temperature during vigorous stirring. When it is finely dispersed, the temperature of the mixture is raised slowly to about 95 C, at which point the water will continue to evaporate with little further rise in temperature. The steam will bubble out of the mixture, which is sufficient fluid to cause only slight increase in volume. When most of the water has evaporated, the temperature will rise suddenly. At about 125 C heating is discontinued.

21. Use of Rubber in Road Surface Preparations, Engineering (36 Bedford St., London, W. C. 2), Vol. 192, No. 4987, p 642, November 17, 1961.

The inclusion of rubber with bitumen material for road surface preparations is found to produce a greater viscosity than possessed by the original bitumen, plus an increase in the elasticity. The changes are dependent on the amount and type of rubber, the temperature and time of heating, and the degree of dispersion. In general, the viscosity of a rubberized bitumen mix initially rises with time and after reaching a maximum decreases. The temperature required to produce maximum viscosity is usually between 140 deg and 180 deg C, depending on the type of rubber. The initial increase is associated with an increasing degree of dispersion of the rubber throughout the bitumen and slight vulcanization of the rubber due to the presence of sulphur in the bitumen. The subsequent decrease in viscosity is related to the degradation of the rubber.

The effective rubber content is defined as the concentration of undegraded rubber which must be added to bitumen to give the same specific viscosity as the test sample. It enables differentiating between the various types of binders which may be prepared with the same amount of rubber but which, through differences in the periods and degrees of heating may finally have considerably different rheological properties.

Natural rubber used in bituminous road surfaces generally consists of one of the following: harcrumb, a lightly unvulcanized rubber powder containing about 96 percent rubber; pulvatex, an unvulcanized rubber powder containing about 40 percent of infusorial as a filler, manufactured at present in Holland; rohorub, a powder produced in Malaya, lightly vulcanized and containing 75 percent rubber; latex and revertex, concentrated natural emulsions of rubber containing 60 to 70 percent rubber and 40 to 30 percent water.

In the preparation of rubberized bitumen, blending is by heat and agitation; the more violent the agitation and the higher the temperature the shorter the blending period required.

Research work on the use of rubberized bitumen is being conducted jointly by the Natural Rubber Bureau, the Road Research Laboratory at Harmondsworth, and the Natural Rubber Producers' Research Association. Several sites throughout the country are being used for full scale experiments with rubberized materials, and in all cases there has been an increased resistance to cracking. A report - Natural Rubber for Research, a Review of Research and Development - describing the joint work has been published by the Natural Rubber Bureau (19 Buckingham Street, London WCL) as Technical Note No. 3.

22. Some Viscous and Elastic Properties of Rubberized Bitumens, L. M. Smith. J Applied Chem v 10 pt 7 July 1960 p 296-305.

Mixtures of bitumen with powdered rubber and bitumen with rubber latex were tested for penetration and softening point, viscosity and elastic strain recovery, and low temperature extensibility; effects observed are due to mechanism which involves molecular (or near molecular) dispersion of rubber in bitumen; for heat-stable mixtures, it is advisable to exclude sulphur of other peptizing agents.

23. Effect of Various Rubbers on Properties of Petroleum, R. H. Lewis, J. Y. Welborn. Pub Roads v 28 n 4 Oct 1954 p 64-89; see also Roads & Eng Construction v 92 n 10 Oct 1954 p 116-20, 143, 146-159.

Laboratory studies on effect of rubber on bituminous paving mixtures; type of rubber used in blend affects asphalt in varying degree; natural and GR-S type II synthetic rubbers produce large changes; polybutadiene rubber produce medium changes; reclaimed, processed, tire scrap, and GR-S Type V synthetic rubbers produce only small changes. Bibliography.

24. Estimating Rubber in Asphalt, G. Salmon, E. Pezarro-Van Brussel, A. C. Van den Schee. Analytical Chem v 26 n 8 Aug 1954 p 1325-8.

With growing tendency to add elastomers to bitumen and asphalt for roads, method is required by which polymers can be estimated quantitatively; how raw or vulcanized natural or synthetic rubbers may be separated from stone chippings in asphalt by prolonged extraction with xylene, or etc; rubber reacts with sulphur and rubber content is determined from analysis of purified ebonite.

25. Laboratory Study of Rubber-Asphalt Paving Mixtures, H. M. Rex, R. A. Peck. Pub Roads v 28 n 4 Oct 1954 p 91-8.

Mixtures consisting of aggregate and combinations of rubber and asphalt have been compared directly with control mixtures containing asphalts; effect of adding rubber to bituminous mixture; types of rubber studied; comparing temperature susceptibility of mixtures; rubber more effective when preblended.

26. Rubber in Today's Bituminous Road Construction, J. R. Benson. Western Construction v 29 n 9, 10 Sept 1954 p 61-3, Oct p 77-8.

Sept: Asphaltic materials may be improved by use of certain types of rubber; although first used in France in 1898, real value of asphalt with rubber became apparent after advent of synthetic rubber. Oct: Effects of rubberizing on durability of bituminous roads; specification change requirements.

27. Report on Use of Rubber in Bituminous Pavements, H. K. Fisher, Pub Works v 85 n 11 Nov 1954 p 73-6.

Work being carried out at Natural Rubber Bureau Research Lab. to determine physical changes occurring in paving mixtures by addition of various types of rubber to aggregate prior to introduction of asphalt to paving mixture, and effect of addition of rubber to bitumen, both penetration and cut back grades.

28. What's New in Asphalts, W. F. Winters. Petroleum Refiner v 34 n 4 Apr 1955 p 125-6.

Production of rubberized asphalt; rubberizer composed of synthetic rubber and barytes added in powder form to asphalt mix; applications in highway construction.

29. Influence of Rubber on Brittleness and Viscosity of Bituminous Materials, P. Mason, E. N. Thrower, L. M. Smith. J Applied Chemistry v 7 pt 8 Aug 1956 p 451-9.

Rubber-bitumens and sand asphalts made with rubber-bitumens, investigated and compared with results obtained with similar material not containing rubber; results show that incorporation of rubber produces material with marked increases in resistance to deformation and reduced brittleness at low temperatures.

30. Combining Rubber and Asphalt for Road Paving. A.E.H. Dussek. Roads and Eng Construction v 89 n 12 Dec 1951 p 86-7, 122-4.

Value of rubber as component of asphaltic paving; particular advantages of scrap tire rubber; rubber asphalt surfaced street in London, England, has served for 13 yr without maintenance.

31. Rubber Roads Have Proved Safer, Less Costly, H. S. Firestone. Rubber Developments (issued by Brit Rubber Development Board) v 5 n 1 Spring 1952 p 20-1

Rubber road is basically standard asphalt pavement into which powdered rubber has been thoroughly mixed; it would take 4,500,000 tons of rubber to resurface present 1,500,000 mi of American highways.

32. Survey on Use of Rubber in Bituminous Pavements; 1945-1951, B. J. Clinebell and L. E. Straka. Rubber Age (NY) v 70 n 1 Oct 1951 p 69-71.

Conclusions from review of literature; standard methods used to prepare rubber powder; improved properties of bitumen obtained by use of 5% special synthetic rubber powder indicate that synthetic rubber may be better than natural for road surfaces; high carbon blacks, tread type compound best for asphalt road surfaces; proportions of rubbers used.

33. Use of Rubber in Bitumen for Road Surfacing. Engineering v 172 n 4466 Aug 31, 1951 p 268-9.

Experience in Great Britain with trial sections of powdered rubber asphalt surfaces; bitumen was 60-80 penetration heated to 300 F, to which 2½% by weight "Mealorub" rubber powder was added; results indicated that rubber bitumen spraying is superior to ordinary bitumen spraying, patticularly with regard to adhesion of aggregate to road surface.

34. What is Rubber Road? A.E.H. Dussek. Rubber Age & Synthetics v 32 n 5 July 1951 p 158-60.

Over past 20 yr author has used rubber of many kinds in various forms of road construction; he is convinced that 7-8% rubber, when used finely ground vulcanized form, preferably from scrap tires, will form important part of every standard specification of bituminous road, including tar macadam, tar spraying, dressing, carpeting, etc; no benefit from ½% admixture.

35. Mikroskopische Untersuchungen von Kautschukdispersionen in Bitumen K. Nachtigall, T.G.F. Schoon. Kolloid Zeit v 156 n 2 feb 1958 p 122-32.

Microscopic examinations of rubber dispersions in asphalt; results show that rubber in aspahlt-rubber powder mixtures is colloidal form dispersed from molecular aggregate reference to recommendations of J. R. Benson on new concepts of rubberized asphalts.

36. New Rubberized Asphalt for Roads, J. York Welborn, J. F. Babashak, Jr. ASCE--Proc v 84 (J Highway Div) n HWa May 1958 Paper n 1651 22p.

Rubberized binders used in surface treatments and seal coat construction are tougher, reduce tendency of surface to crack and bleed, and improve aggregate retention; special rubber additives and processed needed for rubberizing asphalts; use of sulphur, effect of dry rubber additives and other elastomers; study of different asphalts, and process for preparing large volumes of rubberized asphalt.

37. Field Experiments with Powdered Rubber in Bituminous Road Construction. T. E. Shelburne and R. L. Sheppe. Rubber Age (NY) v 66 n 5 Feb 1950 p 531-8.

Results of experiments with powdered rubber carried out by Virginia Dept Highways on US Route 250, West of Richmond; in section 1 powdered natural rubber was incorporated in bituminous concrete sand asphalt wearing surface; section 2 was similar surface to which reclaimed powdered rubber was added; third section was seal treatment with cut back asphalt (RC-2) to which natural powdered rubber was added and mixed prior to application.

38. Natural Rubber Powder in Roads, H. K. Fisher. Rubber Developments (issued by Brit Rubber Development Board) v 2 n 4 Dec 1949 p 10-2.

Report on tests for determination of within-place value of asphalt rubber paving materials; commonly used in highway construction; in all cases rubber was added to existing paving specifications; data support statement that cost of rubber powder added to asphalt paving is more than offset by benefits received.

39. Rubber Asphalt Roads. Roads & Road Construction v 28 n 330 June 1950 p 182-3.

New development sponsored by powdered rubber into cold asphalt surfacings; report on experimental work; powdered rubber made from natural latex was added to mix to extent of ½% by weight of normal constituents of carpet; spreading rate of bitumen emulsion is 28 sq yd per ton; test surfaces were made partly with, partly without precoated granite chips.

40. Rubber Tested in Bituminous Roads, M. E. Dowd. Better Roads v 20 n 1 Jan 1950 p 31-3.

Report on experimental projects which used rubber admixed with bituminous concrete and sand asphalt and used as seal coat; test results.

41. Rubberized-Asphalt Road Surface. Engineering v 169 n 4396 Apr 28, 1950 p 469; see also Eng v 189 n 4919 May 5, p 550.

Material consisting of admixture of powdered rubber, produced from fresh latex, with asphalt, being given trial in Borough of Lambeth, London; similar experiments, initiated in United States, understood to be favorable.

42. Development and Use of Rubber in Bituminous Pavements, H. K. Fisher, India Rubber World v127 n 2 Nov 1952 p 220-2.

Urgent need of prompt action by highway officials to improve street and highway pavements; problems of rubber in roads; method of introducing rubber into paving materials; laboratory established at Rosslyn, Va. by Natural Rubber Bureau; all types of standard testing equipment installed for use in work on rubber in roads; laboratory results to date; economic value of rubber bitumen pavements; as compared to straight bitumen types.

43. New Jersey Lays Rubberized Test Section. Better Roads v 23 n 7 July 1953.

Compound of plasticized rubber mixed in with bituminous top course as laid over concrete on heavy traveled highway is now under observation on 4 miles section of eastbound lanes of U S Route 30; existing concrete pavement estimated to be 30 yr old.

44. Rubber in Pavements. Pub Works v 84 n 7 July 1953 p 69-70.

Experience with test streets laid with rubber as admixture in asphalt in Holland; in United States rubber has been combined with bituminous material and has been used in granular crumb state as portion of mineral aggregate; comments of engineers on rubber pavements.

45. Report on Use of Rubber Compounds in Asphalt Mixes, P. Shafer, W. H. Metzler. Better Roads v 31 n 8 Aug 1961 p 15-16, 134.

Experience in Ohio indicates that savings of 10-18% can be effected with use of rubber additive in MC-5 asphalt in low and high type surfaces; lighter than normal application will hold aggregate cover.

46. Use of Rubber in Road Surface Preparations. Engineering v 192 n 4987 Nov 17 1961 p 642.

Inclusion of rubber with bitumen material is found to produce greater viscosity than possessed by original bitumen, plus increase in elasticity; natural rubber used generally consists of unvulcanized or lightly vulcanized powder or concentrated natural emulsions of rubber; blending is by heat agitation.

47. Toepassingen van Rubber-Asfaltmegsels, H. A. O. W. Geesink, Technisch Wetenschappelik Tijdschrift v 27 n 4 Apr 1958 p 79-83.

Use of Pulvatex, Mealorub and waste rubber as additives to bitumen; test methods outlined; results indicate Pulvatex, unvulcanized rubber powder, is best suited as it is easily incorporated; rubberized asphalt prevents road surface cracking, gives greater impact resistance, and binding medium is tough and shows good cohesion and adhesion; application to top or wearing coat of roads, and as mastic asphalt on bridge surfaces.