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DESIGN OF ASPHALTIC OVERLAYS OVER FLEXIBLE PAVEMENTS

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DESIGN OF ASPHALTIC OVERLAYS OVER FLEXIBLE PAVEMENTS

1. Asphalt Mixture Behaviour in Repeated Flexure, Carl L. Monismith, Kenneth E. Secor, and Edward W. Blackmer, AAPT, 1961, Vol. 30 p. 188.

Proper design of asphalt paving mixtures of heavier duty highwasy necessitates that the engineer insure that a mix not only has adequate resistance to deformation under load (stability) and resistance to weathering and abrasive action of traffic (durability) but also have the ability to bend repeatedly without fracture (flexibility or fatigue resistance). In recent years this latter property has received considerable attention based on evidence presented from field observations of cracking pavements due to repeated bending (1,2) supported by laboratory research data indicating that asphalt mixes demonstrate fatigue with repeated flexure (1,3,4,5, 6,7).

At the University of California, research has been continuing for a number of years on the behavior of asphalt paving mixtures in repeated flexure. Data have been presented (3,4) illustrating the effects of a number of mix variables on paving mixtures subjected to repeated bending. A number of other organizations have also been conducting research (5,6,7,8) in this area. It is the purpose of this paper to (1) summarize the results of current investigations, (2) attempt to define the effects of a number of mix variables on fatigue behavior in terms of these published data, and (3) to present and discuss results of tests which explore two areas not usually covered in laboratory studies of repeated flexure. The first of these areas has to do with frequency of load application. Normally, laboratory tests are performed at frequencies of load application that are constant and - to obtain results quickly - much higher than those resulting from actual traffic; this paper illustrates data for a range of frequencies, similar to those likely to occur for a range of actual traffic frequencies. The second area is related to reversal of stress and strain. Many laboratory tests subject asphalt mixtures to unidirectional bending, producing a change in stress and strain from zero to some finite value in either tension or compression and back to zero again; this paper illustrates data for tests involving a stress reversal from tension to compression, such as is known to occur in pavements under actual traffic.

2. The Effect of Traffic on the Density of Bituminous Paving Mixtures, W. H. Campen, J.R. Smith, L. G. Erickson, and L. R. Mertz. AAPT Vol. 30 p. 378.

In connection with papers on methods of design of bituminous paving mixtures the effect of traffic on the ultimate density has always been questioned. The point has been well taken since it is suspected that extremely low air voids reduce stability and thereby lead to the development of ruts and wash board effects.

This paper presents data on the effect of traffic on streets in the City of Omaha, Nebraska. The investigation has been made on streets included in a ten-year resurfacing program and was carried on jointly by the Department of Public Works of Omaha and the Omaha Testing Laboratories.

The streets investigated were resurfaced in the years 1955 to 1959 inclusive. Approximately 50 miles were resurfaced during this period. Three or four representative projects from each of the years are included in the research. The area covered by these projects is approximately 400,000 sq. yds. and the length involved is 15 miles.

The new surfaces varied in thickness from 1-1/2 to 2 inches and were placed on old asphalt, new binder, brick and old concrete pavements. For the most part, the mixtures were laid on arterial streets or main throughfares. The grade on the streets varied from practically level to 5 percent.

The specifications for the mixtures were based on earlier research and field correlation work. Some of the research was reported to the AAPT in 1948.

3. The Effects of Using Crushed Gravel as the Coarse and Fine Aggregate in Dense Graded Bituminous Mixtures. Presley A. Wedding and Richard D. Gaynor. AAPT Vol. 30 pp. 469, 1961.

In order to get an overall picture of the effect of aggregate particle shape on dense graded asphaltic concrete, mixes were made under varying conditions. These variations were (a) asphalt content, (b) aggregate grading, (c) per cent of crushed particles in the coarse aggregates, (d) type of sand (natural or crushed). In all, over 300 specimens were made and tested.

The results indicate that for this particular test the use of crushed gravel as the coarse aggregate produced mixes of considerably higher stabilities than those containing natural gravel. The use of crushed gravel sand in the mix produced some increase in stability over mixes made with natural sand. The conclusion is that this test crushed gravel sand could not be used in place of crushed gravel coarse aggregate without sacrificing strength. It is suggested, however, that a combination of crushed sand and gravel having an intermediate amount of crushed particles could result in a most efficient mix design.

4. Design Parameters for Layered Pavement Systems, John P. Nielsen and Robert J. Lowe, AAPT 1961, Vol 30 pp 520.

The Layered Pavement Method for the design of flexible pavements has been adopted by the Bureau of Yards and Docks for airfield pavement design. The U. S. Naval Civil Engineering Laboratory has a device (mechanical subgrade) which simulates the action of a natural subgrade and provides a facility in which typical pavement sections can be built and subjected to plate bearing tests. Two and three layered pavements have been constructed and tested in the mechanical subgrade. The objective of these studies is to provide values for the design parameters; modulus of elasticity, and Poisson's ratio, of various types of materials used in designing airfield pavements by the Layered Pavement Method. Theoretical analyses have also been undertaken to produce the settlement influence curves which correspond to the boundary conditons of the mechanical subgrade.

Select base, crushed rock and sand have been used to construct two and three layered systems. Analysis of these tests indicates that the modulus of elasticity is dependent upon the depth of the base and that thin bases (8-inches) in two layered systems do not perform as expected. These thin bases undergo excessive settlements and cracking and rutting of overlying wearing surfaces will be imminent. Closely associated with both the increase in the modulus of elasticity with depth and the excessive settlement of thin bases is the observation that compaction of the base is not the sole criteria for stability and that development of a mechanical bond in the form of article interlock is essential.

5. Cooperative Study of Pavement Thickness, Highway Research Board Bulletin, No. 133, pp. 1-15.

The principal objective of this study sponsored by the Committee on Flexible Pavement Design was to develop information from cooperative testing of materials which would serve to compare the many different methods currently in use for determining the thickness of flexible pavements. In the expectation that definite information would be obtained regarding the necessary thickness of the pavement in the WASHO Road Test to carry certain prescribed loads, the committee decided that the materials composing this pavement should be used as a basis of the study. Samples of the subgrade soul, base and subbase materials were furnished to 19 state highway departments laboratories with the request that after studying the materials they submit an estimate of (a) the thickness of pavement structure necessary to withstand 200,000 trips of each of the four test vehicles, and (b) the failure of the various sections of the test pavement.

For the test sections having 2-in. bituminous surfaces there was good aggreement between the average estimated total thicknesses of pavement as reported by the participants and the thicknesses which, by traffic testing, were found to be sufficient for the respective loads. However, for the sections having 4-in. bituminous surfaces the average estimated thicknesses (surface, base and sub-base) reported were considerably greater than those found from the road tests to be actually necessary.

With respect to the estimates of the number of trips necessary to fail the various sections of the test road there was a large diversity in the answers, clearly indicating that much more attention and study should be devoted to this phase of pavement design.

6. Rejuvenating Highway Pavement, Highway Research Board Bulletin 123 pp. 1-10. J. L. Stackhouse, Maintenance Engineer, Washington State Highway Commission.

The paper describes the resurfacing with a flexible pavement of the Roy Junction - Muck Creek section of Primary State Highway 5, located 6 miles south of Tacoma, Washington, on the route to Mount Rainer National Park that was originally paved in August 1914, with a 16-foot wide portland cement pavement. This section 5.46 miles in length was widened to 22 feet in 1940, using a 3 inch depth asphaltic concrete base mixture as a widening medium and the widened roadway was resurfaced with an average thickness of 2½ inches of asphaltic concrete materials.

A description of the type of soil underlying the pavement is given and the condition of the old pavement before resurfacing. Figures show typical sections before and after resurfacing and after 14 years of service.

The typical grading of the base, leveling and wearing surface mixtures is outlined along with the type and character of the mineral aggregates used and on the grade and source of asphalt cement. A brief description of the methods and types of equipment used in construction of the resurfacing is given, also the length of time and the cost to construct the project.

A table indicating the cost of maintaining this section of highway per year per mile is presented, also the average daily traffic for each year. Slides showing the crack patterns that have developed during the 14 years of this pavement's life are shown with an analysis of the cause of each type.

The paper is concluded with an attempted evaluation of this resurfacing work, pointing out the weaknesses that have developed and how possible correction can and has been made in this type of construction.

7. Progress Report on Laboratory Traffic Tests of Miniature Bituminous Highways, Thomas L. Speer, AAPT Vol 29, p 316-361 1960.

Heavy truck traffic deterioration studies of bituminous roads were obtained indoors with two complex simulation machines. One of the devices duplicates various road construction operation in the research laboratory. Subgrade soil, rock base and two or more courses of asphalt hot mix are fabricated into small experimental pavements. Sixteen of these miniature highways fit into the second machine. Wheel traffic of these miniature highways moves over them consecutively on a continuous 24 hour schedule. Automatic instruments are in control of the program.

Vehicular wheel weights ranging from the compact car class to the largest over the highway transport are produced with the traffic machine. Actual highway speeds are obtained with the equipment. At 25 miles per hour more than 1,400,000 wheel loads roll over each test pavement per week. Torque forces applied to the roads appraoch jack-rabbit starting and panic braking conditions. Slab flexing duplicates the curavatures measured on actual pavements. Many highways enviromental conditions are employed. Subgrade support modulus is varied over wide limits. Effects of soil moisture and rainfall are present. Large temperature gradients are set up. Infrared heating is employed. Pavements and subgrades are frozen and thawed. Near ultraviolet radiation induces asphalt aging processes. Forces associated with these test factors quickly produced defects which are characteristic of old worn blacktops. During the short span of initial testing deep pavement ruts, rough bumps, fine cracks, subgrade pumping and both lateral and longitudinal asphalt slab shoving occurred.

Results of initial truck traffic studies following about 1,000 hours of truck traffic and the passage of more than 10,000,000 wheel loads suggest (1) rutting, shoving and roughening of fine dense grades pavements is not related directly to the type of asphalt cement within the range 60 to 200 penetration; (2) road roughening is significantly related to the degree of pavement heating induced by solar radiation; (3) sensitivity to roughening during rather mild heating to temperatures between 120 and 150 F. is critically dependent on the asphalt content of the pavement; and (4) bituminous slabs break-up quickly during cyclic applications of freezing and thawing forces when very thin ice lenses are present in the clay subgrade soil.

A step-by-step summary of roadway fabrication, laboratory traffic and highway enviromental test operations together with physical property data for pavement and subgrades is given in this report. A group of photographs, each with an informative title, portray this phase of miniature highways in some detail in the appendix.

An important reason for a progress report immediately following the conclusion of testing on the initial set of miniature highways is to provide an early opportunity for discussion of the various techniques employed. The thoughts, ideas and comments of professional highways engineers regarding the deterioration mechanism of blacktop paving fill an important function in program planning. Such suggestions are very helpful in establishing satisfactory objectives and good slab failure criteria for subsequent development stages of minature highway studies. Applied research workers frequently do not posses good oriéntation and usually have very limited experience in this area. When these progress reports are made at an early date, results of the discussions can be readily incorporated into the test program without delay or large expense for modification for the experiment.

8. Flexible Pavement Design Based on Benkelman Beam Rebound Measurements, E. B. Wilkins and Gordon D. Campbell, AAPT Vol. 32 1963 pp. 412-445.

This paper describes a method of flexible pavements design based on Benkelman Beam Rebound measurements. The procedure is applicable to the design of an overlay for an existing pavement while in the design of a new pavement an existing pavement is used as a prototype for the evaluation of strength and establishment of the thicknesses for the pavement structure. The strength evaluation procedure employing the standard CGRA Benkelman Beam Rebound test is described. Mimimum strength requirements expressed in terms of Benkelman Beam Rebound values which will ensure satisfactory performance are suggested.

9. Line Stabilization Cuts Runway Costs, A. R. Kelley, Civ Eng (NY) v 31 n 1 Jan 1961 p 50-1. Report on use of broken up asphaltic pavement and old gravel base mixed in place with lime slurry as subbase for reconstructing 4200 ft of instrument landing strip runway 7300 ft long and 150 ft wide at Austin, Texas; old material stabilized with 3 % by volume of hydrated lime, serves as subbase for new 4½ in. flexible base course and 2 in. hot-mix pavement.

10. Recommandations for Use of Bitumen Emulsion (Anionic) for Roads. Brit Standards Instn-Brit Standard 2542 1960 21 p.

Recommendations apply to emulsion for preparation and treatment of road surfaces carrying wheeled and foot traffic; general aspects, with particular references to contractual considerations; surface dressing, grouting, retreading, premixing, mist spraying, tack coating, and concrete curing.

11. Reflection Cracks in Bituminous Resurfacing, M. M. Davis, Toronto Univ-Dept Div Eng Report 12 1960 68 p.

Theory of behavior, description of test site and initial condition of road, construction techniques used and recommendations governing use of steel reinforced bituminous resurfacing material to correct problem of crack reflection.

12. Betrachtungen uaber die Answendungsgbeite von Asphaltbelaegen im Stadstrassenbau, H-J.von Stosch. Bitumen v 23 n 1 Jan 1961 p 7-10.

Field of application of asphaltic covering in road construction; experience with bituminous covering of existing paving stone and gravel street surfaces in Hamburg, Germany; thickness of covering, conforming to traffic density, was from 65 kg/sq m to 180 kg/sq m; method of application; old surface was smoothed by patching before application coat.

13. New Product for Asphalt Maintennance, B. A. Vallerga. Western Construction v 35 n 12 Dec 1960 p 54, 58-9, 62.

How produce called Reclamite is used to revitalize and replasticize asphalt surfaces that have become dry and brittle by weathering; it is composed of petroleum oils and resins in emulsified form; product is red in color, and change in color, after spray application is index of rate at which penetration is being achieved; product cannot overcome other damages than those caused by weathering and so cannot replace mainteance.

14. Compaction Requirements for Soil Components of Flexible Airfield Pavements. US Army Engineer Waterways Experiment Station-Tech Report n 3-529 Nov 1959 28 p.

Degree of compaction required at different depths in soils beneath flexible airfield pavements constructed for use by air craft with h-p tires and multiple wheels; data from pavements in actual service and accelerated traffic tests on controlled section correlations between compaction effort applied to flexible pavements by aircraft traffic and resulting densities at various depths; use of correlations in preparing compaction requriements.

15. Road-Surface Maintenance in Maine, P. Johnson, Civ Eng (NY) v 30 n 1 Jan 1960 p 73-5. There are 7700 mi of roads with bitiminous treatment applied to gravel surfaces; retreatment of roads consists of "mulch" treatment; mulch operation takes out

slight irregularities, most of high-type pavement used on heavily traveled highways is bituminous concrete; applying bituminous concrete on old concrete pavement; filling of cracks with RSI emulsion; problems of snow fencing, snow removal, sanding, and salt treatment.

16. Rolled Asphalt Bitumen and Flaxed Lake Asphalt (Hot Process). Brit Standards Instn-Brit Standard n 594 1958 43 p.

Standard specifies requirements for asphalt with igneous and calcareous rock or with gravel or slag aggregate; it deals with single course asphalt and with two course asphalt comprising base course on which is laid wearing course; requirements for asphaltic cement for general use, and for special use where high rainfall and/or colder conditions prevail; properties of materials and composition of mixtures, methods of transportation and laying, etc. are specified.

17. Application of Rational Design of Flexible Pavements, S. A. Kleyn S African Instn Civ Engrs-Trans v 8 n 11 Nov 1958 p 387-408.

In Design of Flexible paving, elastic deformation or deflection and plastic deformation or settlement must not exceed certain specific limits, and shear stresses induced in pavement must not exceed shear resistance of system; distinction between and method for evaluating both elastic and plastic deformation; methods for estimating both in multilayered systems.

18. This Problem of Skid Resistance, A. T. Goldbeck, Crushed Stone J v 33 n 1 Mar 1958 p 21-7.

Factors influencing skidding; slipperiness tests on road surfaces; concrete surfaces become polished by use; if improper mix was used in bituminous surfaces, asphalt may be squeezed out to road surface on hot days; role of locked wheels better brake systems needed which keep rolling wheels on slippery surfaces; "sipe" in tires helpful; coat of asphalt-sand mixture used against slipperiness.

19. Maintenance and Repair, Fabric Laid on Concrete for Airport Resurfacing, F. G. Wakefield. Pac Bldr & Engr v 62 n 12 Dec 1956 p 72-3.

Bituminous resurfacing of Willow Run Airport, Mich, with wire Fabric reinforcing; preparation of concrete pavement consisted of removing 42½ slabs; while slab replacement was in progress, 2-lane area of main west ramp was prepared; 10-in thick base of

100% crushed stone aggregate replaces slabs; aggregte was compacted by 12-ton tandem roller, then base area was primed with AE-2 tack coat.

20. Control in Manufacture and Laying of Bituminous Surfacings, H. G. Barnes, Instn Mun Engr--J v 83 n 6 Dec 1956 p 195-204.

Control of surface dressing work; control to be exercised before surface dressing work is started, during laying of surface dressing, when mixing and laying premixed surfacings at mixing plant, and during laying of surfacing.

21. Slurry Seal-Where and How to Use it, M. L. Nelson. Western Constr v 32 n 2 Feb 1957 p 25-7.

Slurry seal cannot be used to build up structural section and must be applied before structural deterioration of existing pavement has occurred; mixture has low inherent stability and must be used in thin layers strictly as surface treatment; mixture has excellent possibilities in rejuvenating old,dried and oxidized bituminous pavement; description of mixing procedure.

22. We Put End to Patching Headaches, W. Priday, Am City v 72 n 5 May 1957 p 124-5.

Road surface patching techniques used in Anahaim, Calif; application of surface material is accomplished by towing Rola-Paver behind truck loaded with surfacing material; paver lays blanket of mix to any thickness desired from ½ in. up as much as 12 in.; its own weight provides about 25% compaction; mix used consists of 3/8 in. max size aggreate combined with 120-150 penetration grade asphalt as approximately 200 F.

23. Bituminous Resurfacing, Nat Research Council-Highway Research Board Bul n 123 1956 39 p.

Rejuvenating Highway Pavement, J. L. Stackhouse Conditioning Existing Concrete Pavement for Bituminous Resurfacing. F. W. Kimble; Condition Surveys of Bituminous Resurfacing over Concrete Pavement, L. W. Crump, A. J. Bone; Current Practices and Research on Controlling Reflection Cracking, A. J. Bone, L. W. Crump Bibliography.

24. Flexible Pavement Design Correlation Study. Nat Research Council-Highway Research Board-Bul 133 1956 38 p.

Report on correlation study of design methods made by Committee on Flexible Pavement Design; how 19 state highway departments and other agencies, all using same materials of construction, would design pavements for given set of condition as to climate and traffic.

25. Emulsified Asphalt Slurry Coats. Western Construction v 31 n 2 Feb 1956 p 21-3.

Technique for reducing time and costs in sealing cracks in old asphalt pavements; field testing of pre-mixed slurry seals; design of mixture; transit mix truck used; application procedure; cost data.

26. Use Asphaltic Overlay and Stage Construction Techniques. Publ Works v 87 n 8 Aug 1956 p 100-2.

Research and experimentation conducted by U. S. Corps of Engineers, concerning overlay thicknesses requried for any increase in loading overlay thicknesses required for any increase in load carrying strength; overlaying flexible pavements; overlays for rigid pavements; stage construction; application of stage construction techniques in North Carolina; costs and savings.

27. Abstract, Statistical Quality Control Applied to an Asphalt Mixing Plant, AAPT Vol. 23 1954 pp. 78-96.

Economic advantages may be gained in aspahlt mixing plants through the use of Statistical Quality Control charts. An application to an actual job is clearly sketched. Control charts are a basis for action; some typical control chart patterns and the action they dictate are demonstrated.

28. Recent Developments in Equipment Used for Sealcoats or Surface Treatments of Existing Bituminous Surfaces, William H. Schuelie. AAPT Vol. 24 1955 p 242-253.

The author of this paper, who is a manufacturer's representative, discussed equipment needed for sealcoats or surface treatment of an existing pavement.

He discusses the use of self-propelled equipment, patch mixers and, Heater Planers. He emphasized the need for clean surfaces and briefly tells how the area to be treated should be cleaned. He also discusses chip spreaders, rollers, boom drags, and other equipment developed or in the development stage.

29. How to Harden Airport Runway Base, N.C. Bird, Eng News-Rec v 148 n 11 Mar 13 1952 p 60-1.

Airport at Cairo, Ill. has near surface groundwater table; runway of compacted gravel with bituminous surface seal broke up progressively; 41,000 sq yd repaired by applying soil cement; procedure and equipment.

30. Notes on Illinois Practice In Asphaltic Resurfacing, F. N. Barker Roads & Streets v 94 n 11 Nov 1951 p 59-61.

Illinois Division of highways has rehabilitated more than 1500 mi of old rigid pavement by resurfacing with bituminous concrete; details of gage for checking rise of slabs during undersealing; rigid plant requirements.

31. Salvaging Old Pavements by Resurfacing, R. H. Tittle, Nat Research Council-Highway Research Board Bull n 47 1952 35 p.

Data required to make rehabilitation of road effective and efficient; concrete pavements; bituminous pavements; preparation for resurfacing; widening of pavements with resurfacing.

32. Some Aspects of Skidding in Relation to Non-Skid Properties of Asphalt Road Surfaces, Tyre and Vehicle Designs, C. Greville-Smith, Roads & Road Construction v 28 n 329, 330 May 1950 p 140-3 June p 168-72.

Characteristics of skidding: straight skidding by sudden application of brakes; impending skidding when brakes are applied gradually and sideway skidding occurring on curves; asphalt road surface design; maintenance of non-skid properties; rendering existing slippery surfaces non-skid; measurement of road surface characteristics. Bibliography.

33. Bituminous Overlay Strenghens Wartime Fighter Base for Modern Commercial Aircraft. J. H. Gould Roads and Streets v 98 n 10 Oct 1955 p 11-17, 119-21.

Pavement strengthening at Richmonds Richard E. Byrd Field; asphalt specifications; laying, surface treatment and seal.

34. Homestead Airbase: Vast Apron, Fast Paver, Tar-Rubber Mix. Eng News-Rec v 154 n 24 June 16 1955 p 54-6, 58.

Experimental areas at airbase Presque Isel, Me, proved that bituminous paving with a tar and rubber surfacing resists damage from jet fuel spillage and blast from jet aircraft, whereas asphalt surfacing does not; airbase in Homestead, Fla. with its 1150x8000 ft apron, taxiways, warm up pads and 1000 ft of tar rubber surfacing at either end of 11,400 x 200 ft runway will furnish operating experience under different climatic conditions; paving methods and equipment.

35. Materials and Equipment for Bituminous Resurfacing. L. J. Ritter, Jr. Pub Works v 86 n 1 Jan 1955 p 67-74.

Analysis of existing conditions; pavement defects; preparation for resurfacing; resurfacing of portland cement concrete pavements and of bituminous pavements; required quantity of material.

36. Street Resurfacing is Science in Minneapolis. Eng News-Rec v 155 n 15 Oct 13 1955 p 36-40.

Methods used in resurfacing 100 mi of streets carrying abandoned street car lines; in one case 30 ft width of asphaltic concrete is laid over old pavement and rails, in another case, street gets full treatment including widening, strengthening old pavement and resurfacing with asphaltic concrete, new curbs and gutters and perhaps new lighting.

37. Investigation of Road Foundation Failures, W. W. Lewis, Great Britian Dept Sci & Indus Research-Road Research Tech Paper n 21 1950 23 p, 9 supp plates.

Causes of foundation failures and methods employed in examining them; tests and data necessary to assess condition of road structures and subgrade; discussion of typical failures of both flexible and rigid pavements.

38. Heavily Traveled New Mexico Highway Repaved with Hot-Mic Asphaltic Concrete, I. B. Miller and J. D. Reese. Roads and Streets v 94 n 7 July 1951 p 72-76.

Notes on 7 mile project on U. S. 85 entering Raton Pass, New Mexico; project represents new practices designed to equip more heavily traveled highways for present-day weights and volume of traffic.

39. Repaving for Very Severe Conditions. Roads & Streets v 93 n 11 Nov 1950 p 33-7.

Problems on Highway US 41 between Chicago and Milwaukee are discussed; reconstruction on one of worst sections summarized with notes on conditions encountered, methods used, and design variations employed; lean-concrete slab and heavy bituminous blanket placed on 7 mile project, after first fragmenting and rolling old concrete pavement to serve as subgrade.

40. Widening and Resurfacing Old Pavements with Asphaltic Materials, H. D. Helmle. Roads & Eng Construction v 88 n 12 Dec 1950 p 87-8, 102-6.

Suggestions for salvaging investment made in roads that have become worn out or outdated; types of resurfacing; preparing old slab as base; widening existing pavements; costs of resurfacing.

41. Improving Anti-Skid Properties of Bituminous Surfaces, H. H. Harris Better Roads v 21 n 5 May 1951 p 22-4.

Treatment with rock asphalt, precoated sand, or light applications of asphalt or tar found effective in skid-proofing existing slick pavements in Virginia; data on different treatments.

42. High Type Asphaltic Concrete, A. W. TEWS Roads & Streets v 96 n 11 Nov 1953 p 121-4.

Postwar Resurfacing Program of city of Duluth, Minn, called for use of high type asphaltic concrete; since 1945 50 mi of streets and trunk highways were resurfaced; surfacing consisted of aspahltic concrete using ACI, 70-100 penetration material and 100 % crushed trap rock; costs amounted to $1.18 pr sq yd in 1947 to $2.09 in 1952.

43. How to Make Old Roads Fit for Today's Traffic, G. E. Martin, Pub Works v 85 n 1 Jan 1954 p 67-78.

Lack of money relocation, mud-jacking, undersealing, widening, surface improvements, and flexible pavements, existing highways were improved to meet present day demands.

44. How to Improve Asphalt Quality, W. F. Winters, Pub Works v 85 n 4 Apr 1954 p 84-5.

Asphalt road must provide tight, impermeable, smooth nonskid, and adequate wearing surface; asphalt must be adhesive, strong, and tough; snythetic rubbers contain many of quality elements lacking in refined asphalts; production of rubberized aspahlts has developed new concept in asphalt technology; Goodyear Tire & Rubber Co uses rubberbarytes compounds for rubberized asphalts.

45. Making Modern Highways in Pennsylvania, E. L. Schmidt. Pub Works v 85 n 2 Feb 1954 p 61-3, 68.

Example of rehabilitation and salvaging of existing pavement, 13.58 mi long; pavement is widened with 4 to 6 ft of 12 in. crushed aggregate base course and bituminous surfaces; similar procedure with detailed cost data on 4.88 mi road.

46. Pavement Rehabilitation in Oregon, R. Webber, Pub Works v 84 n 11 Nov 1953 p 74-5.

Transition from light to heavier traffic volume and age deterioration necessitated rehabilitation of many miles of roads; tests showed that ideal skid resistant surface is one with sandy texture; asphaltic concrete mixes contaning graded material with about 6% voids is desirable; voids prevent asphalt flushing to surface; check tests include standard road roughness, skid coefficinet, and surface permeability.

47. Extra Dividends of Asphalt Overlay Pavements, J. M. Griffith. Roads & Streets v 96 n 10 Oct 1953 p 94-6, 101. Asphaltic overlays are not only used to resurface over cracks and to "smooth out" irregularities but also increase load-bearing capacity; flexible pavement overlays consist of non-bituminous base plus asphaltic pavement surface; charts developed from which thickness of flexible, rigid, and of non-rigid types of overlays can be read.

48. Terminology and Variety of Bituminous Pavements, R. E. Waslh. Surveyor v 112 n 3183 Mar 7 1953 p 155-7. Hydrocations and other plastic binders; coal tar, road tar and pitch; tar and bitumen surfacings on macadam and concrete; cold asphalt; hot laid carpet; hot compressed, hot mastic and hot rolled asphalt, surface dressing and road emulsions.

49. Road Construction and Maintenance: Influence Thereon of Present Limits in Expenditure and Rising Costs, A. Nicholas. Instn Mun Engrs--J v 79 Jan 1953 p 373-78 (discussion) 379-80.

Surfacing used as temporary means of keeping highways in good status; different types of carpets such as hot rolled asphalt, precoated chippings, [illegible] cold asphalt and cold bituminous macadam; surface dressing; maintenance of concrete roads; post was construction of roads.

50. NONSKID - Danger-Slippery When Wet, C. E. Larson. Eng News-Rec v 151 n 18 Oct 29 1953 p 45-6. Concrete pavement of fine and coarse limestone aggregates results in surface which becomes highly polished; tar and slag chips can be applied to increase skid resistance; examples of slippery highways; it is asserted that slippery surfaces are also due to excess of asphalt; correction of slipperiness.

51. Evaluation of Pavement Performance Related to Design, Construction, Maintenance and Operation, William S. Housel, Professor of Civil Engineering, University of Michigan, and Research Consultant, Michigan State Highway Department, Highway Research Record No. 46 pp. 135-153.

This paper presents a summary of the findings of the Michigan Pavement Performance Study, a five-year program (1958-1963) to evaluate the five year period, equipment and procedures for recording and analyzing pavement profiles have been developed and profiles of 10,000 miles of pavement have been accumulated. Although there have been several published reports of this work as it progressed, the final results have now been compiled and analyzed.

The quantitative evaluation of pavement condition and performance and the physical inventory of existing roads provide factual information of direct value in design, construction, and maintenance of both rigid and flexible pavement and in the operation of the state trunkline system as a transportation facility. The findings of the five-year study are reviewed, the adequacy of Michigan design standards is evaluated, and the effect on performance of certain construction practices is pointed out. The use of pavement profile data in more effective and timely maintenance and their value in the operation of the state highway system are discussed.

52. Preface - Highway Research Board Special Report No. 8, Connecticut Highway Maintenance Production Study p. iii A. L. Donally, Eng. of Roadway Maintenance, Connecticut State Highway Department.

The report "The Connecticut State Highway Maintenance Production Study" meets one of the basic needs of the highway administrator for facts concerning the performance of the day-to-day maintenance functions. Field work on this pioneer study was completed in Aug 1951; preliminary drafts of the final report were made available in November 1951. Since this latter date meetings of Department headquarters and field supervisory maintenance personnel have been held concerning improvements of maintenance performance and practices growing out of detailed consideration of the report. By April 1952, through the authorization of Commissioner G. Albert Hill, several obvious improvement needs had been effected; others will require continued study and efforts. In many instances there has been a general awareness in the maintenance organization of the need for such improvements. For the first time, however, the facts contained in the report show the magnitude of the problems involved; they also provide a basis for measuring and comparing the results obtained through different practices. This plan of continuous appraisal of field maintenance methods and practices is now (April 1952) established as a routine Department procedure and is one of the most valuable by-products of the study.

53. A Study of Tenacity of Aggregates in Surface Treatments, H. E. Schweyer, William Gartner, Jr., Respectively, Department of Chemical Engineering. University of Florida; and Division of Research, Florida State Road Department, Highway Reasearch Record No. 104 p 18-35.

A study was made to develop a tenacity test for measuring chip retention in surface treatment. A laboratory procedure is described for forming a monolithic structure on the surface of a simulated roadbed made up on a metal panel. The aggregate chips were encapsulated on the surface so that the entire mass could be pulled away from the roadbed and the strength of the bond between the aggregate and the roadbed determined.

To keep experimental work to a minimum the number of variables studied have been limited to aggregate and asphalt spread quantity, the type, size and size distribution of the aggregate, and consistency of the asphalt. Results cover a number of these variables but are not a complete survey of all of them. To reduce variability of results, test procedures were standaridized carefully and enough samples were tested so that statistical methods could be used with confidence. Additional variables studied by statistical techniques include: (a) effect of moisture and dust in the aggregate, (b) different operators, and (c) the effect of aging before testing.

54. Effects of Mineral Fillers in Slurry Seal Mixtures, William J. Harper, Rudolf A. Mimenez and Bob M. Galaway, Respectively, Assistant Research Engineer, Associate Research Engineer, and Research Engineer, Texas Transportation Institute, Texas A & M University, Highway Research Record No. 104 pp. 36-59.

Slurry seal coats have become useful in maintenance operations during the past few years; however, technology has lagged construction knowledge. Present specifications for slurry seals generally constitute an empirical proportioning of components rather than a design. The primary objectives of this research were (a) to determine the effect of mineral filler (a common additive) and residual asphalt content on the Slurry Seal mixture, (b) to evaluate a new slurry seal testing machine, and (c) to develop a method of design.

A method was for developed estimating the optimum content so that filler effects could be studied at the same level of design. Operating and testing procedures were carefully evaluated for applicability, and the variables of this testing procedure were standarized for th ensuing slurry seal research program. The objectives were evaluated from the test results and from visual inspections of the specimens. The test variables, abrasion, shoving and relative thickness were correlated with a visual rating system. The data show that: (a) abrasion is the best measure to consider when evaluating a slurry seal mixture; (b) limestone dust and cement were better fillers for use with Rockdale slag aggreate; (c) cement and fly ash were more suitable with concrete sand mixtures; and (d) the design equation for predicting the optimum residual asphalt content was valid for slurry seal mixtures when tested in the Moung wet track abrasion device.

55. Effect of Asphalt Viscosity on Rhelogical Properties of Bituminous Concrete, Charles A. Pagen and Bee Ku, Respectively, Assistant Professor of Civil Engineering, and Research Associatd, Transportation Engineering Center, Ohio State University, Highway Research Record No. 104 p. 124-140.

The mechanical properties of bituminous concrete and the rheological response of asphalt greatly influence the design and construction of mulitlayer flexible pavement structures and are directly related to the response of bituminous concrete structures to traffic under various enviromental conditions. The experimental phase of this research involved the testing of five different types of asphaltic concrete mixtures in which two aggregates types are used. Correlations between asphalt viscosity, theological strength moduli, and deformations of the bituminous mixes were developed over an extensive range of loading times and temperatures. The application of the linear viscoelastic theory and the time-temperature superposition concept to define the mechanical properties of asphaltic concrete mixtures was rigorously investigated. An equation of state to describe the load, deformation, time, and temperature-dependent behavior of asphalt concrete is presented. The aggrement of the data in this experimentation provides a verification of the ability of the linear viscoelastic theory to describe the response of asphaltic concrete, as well as of the application of the derived equations of state and the time temperature superposition concept to these materials.

56. Cutback Asphalt Patching Mixtures, J. R. Bissett, Associate Director, Engineering Experiment Station, University of Arkansas Highway Research Board No. 215 pp. 1-13.

Asphalt patching mixtures should be satisfactory for use at all seasons of the year and should have suitable stability if used immediately after mixing or after storage for long periods of time. The additional requirements are that local materials must be used wherever possible and the mixture should be satisfactory for preparing by the maintenance forces in the districts.

In the study reported, one aggregate was chosen for all phases of the project. This material was a hard dolomitic limestone.

Two methods of curing were used for all cutback. The first method was that of curing the prepared mixes in ovens at a constant temperature of 140 F. The second method of curing was in lengths of stovepipe from rain. Thus, the mixture was exposed to the air at both ends of the stovepipe.

Series of mixes using both MC cutter stocks and RC cutter stock were used. The rate of the MC cutbacks indicated that these mixtures could be stored for long periods of time and still be used, but they would cure so slowly in a stockpile that they would not be useable for some time after mixing. Mixes using the RC cutter stocks cured too rapidly.

A Marshall stability of 500 lb was chosen as the desirable minimum stability satisfactory for patching.

A comparison of the distillation cirves of RC cutter stocks and MC cutter stocks indicated that the ideal cutter stock would be one having the characteristics of the lighter ends of an RC with heavy ends of an MC. A blend of 40 percent of RC, 50 percent MC and 10 pr cent SC cutter stocks produced a distillation curve approximating the desired characteristics.

Patching mixtures prepared with blended cutback gave the desired results. From 30 to 40 percent of the volatile matter was lost during mixing and storing. At this point the Marshall stabilities ranged between 400 to 500 lb. Beyond this point the rate of curing was slow thus providing a long period of storage where needed.

A tentative specification for cutback asphaltic patching materials was derived from the study. The specification varies from the usual specification in several important points and is very restrictive. Field use will be required for improvement of the specification.

57. Seal Coats: Laboratory Contributions Toward Better Performance, Ernest Zube, Supervising Materials and Research Engineer, California Division of Highways, Highway Research Bulletin 215 pp. 14-33.

Success or failure of a seal coat can often be traced to lack of control of materials and condition of the equipment. Field tests are needed to enable the engineer to have more positive means for evaluating the actual quality of the work as it is performed. This paper discusses in detail a method for checking the uniformity of the transverse and longitudinal spread rates of the asphalt distributor.

Additional studies and experiments relating to seal coats are described, such as variation in temperatures of the bituminous binder from the time it comes in contact with the pavement to the time of rolling the screenings, degradation of scfeenings due to rolling and traffic, seasonal effect on performance of seal coats and permeability of pavements. The use of atometers for determining drying conditions and setting time of the bituminous binder, particularly asphaltic emulsions, was investigated. The possible use of a simple centrifugal test which can be performed in the field to predict the adherence of screenings is discussed. This test should provide the engineer with some evidence as to a proper waiting time before opening the newly placed coat to traffic.

58. Iowa State Highway Maintenance Study, Highway Research Special Report 65 p.

This report contains results of a one year study (August 1959 to August 1960) of maintenance operations on State Primary and Interstate highways in Iowa. As its general objective, this study undertook (1) to develop, analyze, and report basic information about maintenance methods and procedures, manpower, utilization, equipment production rates, and organization of work and crews, and (2) to present recommendations concerning any aspect of maintaining the State primary road system including interstate routes.

Research techniques were used in the systematic gathering of information of Field operations. Literally, millions of figures were recorded and analyzed. Some of the findings suggest a possible need for making additional appraisals and interpretations of available data to facilitate a goal of high efficiency and economy in highways maintenance work. Even more research of a similar nature, but on a smaller scale, may be required to satisfactorily achieve and keep the desired level of efficiency.

This report contains 7 sections, A through G. Findings are presented in Section E followed by Discussions and Conclusions in Section F. and finally the Recomendations in Section G.

59. Highway Rehabilitation by Resurfacing, H. B. Hirashima, Area Construction Engineer, Teritorial Highway Department, Honolulu, Hawaii, Highway Reserach Board Bulletin No. 131 pp. 26-30.

Old and bumpy pavements, both asphalt and concrete, can in many instances be rehabilitated to serve present traffic needs by means of a one-layer, two-layer, or multiple-layer resurfacing of asphalt concrete. In the case asphalt pavements, some city streets have been rehabilitated with a one-layer resurfacing of an average thickness of 2 1/4 inches.

60. Progress Report on Changes in Asphaltic Concrete in Service, William J. Kennis, Sr., Materials Engineer, Delaware State Highway Department, Highway Research Board Bulletin No. 333 pp. 39-65.

This paper describes the experimental asphaltic concrete pavements constructed in Delaware to evaluate the changes in the properties of mixtures during construction and in service. Two experimental asphalts from specific sources, each laid over a rigid (old portland cement concrete) and a flexible (old surface treatment) base, were used.

The present report includes data from three series of samples, those taken during construction and those taken after one and two years of service. Comparison of results obtained by three different laboratories Bureau of Public Roads, Asphalt Institute, and Delaware State Highways Department also is provided.

At present no specific conclusions can be drawn but laboratory tests indicate that differences in behavior of the same asphalt at various locations in the road may be as great as or greater than differences in the asphalts from the two crude sources used in this study. Other than minor reflection cracking from the concrete base on the rigid sections, no deterioration in the pavements has been noted at any location.

61. Salvaging Old Pavements by Resurfacing, Robert H. Tittle, Chairman, Engineer of Construction, Illinois Division of Highways, Highway Research Board Bulletin No. 47, pp. 1-30.

A majority of the pavements twenty years and older have reached the stage where maintenance costs are excessive to keep them in a passable condition. There are many miles of old pavement which can be made serviceable for an extended period by placing an adequate surface over the existing pavement. Resurfacing may consist either of portland cement concrete or bituminous surfaces. By widening at the same time, present and anticipated traffic can be accomodated for several more years. In a rehabilitation program of this nature there are many questions involving economics, design, traffic, materials, and construction to be considered.

Resurfacing deteriorating pavements is now recognized and accepted by many states, counties, cities, and the Bureau of Public Roads as an economical, convenient, and highly satisfactory means of salvaging old pavements. It has proven adequate to serve the increased wheel loads now operating on the streets and highways. In addition to providing a smooth, skid-resistant surface, resurfacing imparts considerable strength to the road structure by waterproofing the subgrade, reducing impact stresses, and by the addition of its inherent, strength.

In the preparation of this report only the higher types of resurfacing treatments have been given consideration. A high type of bituminous resurfacing treatment is considered as having a minimum thickness of 2 in. An attempt has been made to cover the most suitable method. Although it has not been possible to consider all types of treatment, those covered are sufficient to enable engineers without previous experience in resurfacing work to select a suitable type for their need.

62. Highway Research Board Special Report 61C, The AASHO Test Report 3, Traffic Operations and Pavement Maintenance, pp. 1-65.

The AASHO Road Test was conceived and sponsored by the American Association of State Highway Officials as a study of the performance of pavement and bridge structures of known characteristics under moving loads of known magnitude and frequency. It was administered and directed by the Highway Research Board of the National Academy of Sciences National Research Council and was considerably larger and more comprehensive, than any previous highway research study.

This report is the third in a series of major reports on the AASHO Road Test. The first report is a history and description of the project. The second is a detailed account of the materials and the construction of the test facilities. Subsequent reports cover the results of the research on pavements and bridges as well as the results of certain special studies carried out at the test site.

This report is presented in three chapters. The first is a brief description of the project; the second describes the test vehicles, their operation and maintenance; the third covers the maintenance of the test pavements and bridges.

The basic data for this report are availabe in the form of IBM printouts or are on file for review in the Highway Research Board Library. A comprehensive catalog of available data systems may be obtained from the Board.

63. Hastings, A. O. "Resurfacing Rough Pavements with Thin Layers of Bituminous Mixtures," Purdue University, Engineering Extension Department, Bulletin No. 30, pp. 73-80, 1933.

Portland cement concrete, brick on gravel and on concrete base, bituminous macadam and treated stone roads resurfaced with emulsified asphalt mixtures, bituminous concrete, amesite penetration macadam, penetration macadam with rock asphalt surface, rock asphalt on concrete, bituminous coated aggregate with rock asphalt wearing course, bituminous concrete AHMC, bituminous coated aggregate (Pre-Coté) retread surface, includes cost data.

64. Hanes, C. R. "Some Practices Used by Ohio in the Salvaging of Old Pavements." Highway Research Board, Proceedings Vol. 27 pp. 257-273, 1947.

This discussion is limited to widening with nonrigid base of the macadam and bituminous concrete types, and resurfacing with bituminous concrete. An important item in salvage construction is preparation of the pavement for salvage work to follow; this may consist of under sealing or adding an insulation course to surface. Placing of widening with self-propelled strike-off units has improved results and increased production.

65. Anon. :"First Field Test of a New Process for Rejuvenating Old Asphalt Pavement" Western Construction, Vol. 25, No. 9, pp 63-64, September 1950.

Process developed by California Division of Highways in rejuvenating rough old asphaltic pavements; use of newly developed liquid asphalt (Shell Oil Company) softener mixed with windrow of pulverized material from old pavement. Resultant mix relaid on old base is equivalent to a new SC-5 or SC-6 plant-mix surface.

66. Holcomb, W. T. "Nevada Practice in Widening and Thickening Old Road Mix Asphaltic Surfaces with Plant Mix." Western Association of State Highway Officials, Proceedings, pp. 93-95, 1953.

Methods of resurfacing and widening 18 and 20 ft width road mix surfaces with 26 ft width 2 in thick plant mix surfaces. Old gravel and earth shoulders were trenched out and replaced with gravel and plant mix base before being surfaced with the plant mix. An emulsified asphalt seal with chips followed the plant mix surface over the entire 26 ft width.

67. Ten Hagen, Henry, "Rehabilitation of Old Pavements." Association of Highway Officials of the North Atlantic States, Procedings, pp. 94-100, 1953.

Practices of the New York State Department of Public Works in rehabilitation of old pavements by resurfacing; problems of both flexible type and rigid pavements considered; widening operations; reinforcement; subsealing; selection of type of top course.

68. French, L. A. and others, "Getting a Good Lay-Down on Asphalt Paving Work." Roads and Streets, Vol. 97, No. 8, pp 107-108, August 1954, No. 9 p 104, September 1954; No. 11, p 108 Nov 1954.

A series of articles on various highway department practices in resurfacing old pavements, including California, Vifginia, New York, Illinois, Minnesota and Iowa. Informal remarks on problems of essentials of finishing, getting a good centerline joint, proper rolling and getting a good smooth riding job on asphaltic surfaces, especially in resurfacing old pavements of both bituminous and concrete types.

69. Ritter, L. J., Jr. "Materials and Equipment for Bituminous Resurfacing." Public Works, Vol. 86, No. 1, pp 67-74, January 1955.

Discussion of bituminous resurfacing; analysis of existing conditions; preparation for resurfacing; base strengthening of rigid pavements; resurfacing of portland cement concrete and bituminous pavement with both road-mix resurfacing and high type bituminous mixtures; illustrated bibliography included.

70. A Study of the Effects of Aggregate Factors on Pavement Friction, Joint Highway Research Project, Purdue University Lafayette Ind. No. 5, January 1961.

Tests performed on surfaces of controlled shape aggreagte particles gave general indications of the relationship between the effect of edges and particle surfaces. The contribution of the edges to the relative resistance value of larger, smooth aggregate particles was a small increse in resistance. The creation of edges in boldly textured aggregate reduced the relative resistance value.

Area of aggregate exposed in the surface of the specimen and thus available to the rubber shoe for friction had a major effect on the relative resistance value. The greater the ratio of aggregate exposed to the total surface area, the greater the relative resistance value. The rate of this trend was strongest for low ratios, moderate as the area of aggregate approached one-half of the test surfaces, and remained nearly constant thereafter.

Several specimens tested under various pressures showed increased in relative resistance value with increased contact pressure. For coarse aggregate pavement, the rate of increase was dependent on material rather than on aggregate shape. This rate was greater for strongly-textured stone such as sandstone than for soft material such as limestone.

The use of different abrasives for polishing rock cords prior to relative resistance value tests indicated that the degree of polish attained for a given effort is a function of both the rock from which the core was cut and the abrasive used. The use of an abrasive which was harder than the cores caused a continual reduction in relative resistance value as the size of abrasive was reduced. The use of abrasive identical with the cores established that for each material there was a definite size of similar abrasive which gave the surface a polish resulting in the highest relative resistance value. For the limestones used in this study, the abrasive size which resulted in the highest relative resistance value was passing a No. 100 sieve and retained on a No. 200 sieve.

Bituminous mixtures using crushed and round silica sand were used to establish the size of granular surface texture which resulted in the highest relative resistance value. For crushed silica this size was 0.0175 inches in diameter. For round silica, a size below 0.0088 inches was indicated.

71. A Laboratory Investigation of Pavement Slipperiness, J. W. Shupe and W. H. Goetz, Joint Highway Research, Purdue University, Lafayette Indiana, pp. 1-49 Vol. 32 Dec 1958.

Experience indicates that highways which are constructed to conform to current design standards may become dangerously slippery when wet after a relatively short period of wear. As the polishing effect of traffic continues to become more intensified, the incidence of effect of traffic continues to become more intensified, the incidence of slippery sections of pavement will tend to increase. In order to minimize the occurrence of these skidding hazards, the highway engineer must include permanency of skid resistance as a design parameter in selecting a suitable paving mixture.

A laboratory testing procedure was developed at Purdue University to investigate the slipperiness potential of different highway materials, and to predict the resistance of paving mixtures to the polishing effect of simulated traffic. The laboratory testing method, a field correlation study and an accelerated wear and polish procedure are summarized in this report, along with the results of the initial phases of the research which have been reported upon previously (7). Included in this are (1) a report of a polishing characteristic of aggregates in both portland-cement and bituminous mixtures and (2) a study of the effect of surface texture, or degree of openness, and initial aggregate shape on the skid resistance of bituminous mixtures. A more complete discussion is presented of subsequent research in which the effect of blending a polish-resistant material with a polish-susceptible aggregate in both portland-cement and bituminous mixtures was determined, and of a study in which the anti-skid characteristics of fine-grained surface treatments were investigated. A final summary is presented which includes the author's recommendations with regard to design and construction practices that tend to minimize pavement slipperiness.

72. Load Deformation Characteristics of Bituminous Mixtures under Various Conditions of Loading, Joint Highway Research Project, Purdue University Lafayette Indiana, Vol. 17 pp. 1-101.

In this presentation we have attempted to outline a problem existing in Indiana and one which is known to be present in' other areas of the country. We have also attempted to show the laboratory approach to the solution of the problem, first from fundamental considerations of the stress-deformation characteristics of asphaltic mixtures as measured by various methods of test and second from the application of those test methods to the evaluation of bituminous concrete.

While the problem has not been solved in the rigous technical sense, there have been discovery relationships among the factors governing the load-carrying characteristics of bituminous mixtures that should provide a basis for the better understanding of the properties of the material, specially, we would like to point to the following:

A fundamental relationship between the compressive strength of a bituminous mixture and factors of rate of loading and temperatures has been established for two basic types of bituminous mixtures and for a variety of test conditons.

The results of repeated load tests on bituminous mixtures suggest that this type of test might provide valuable information concerning the plastic nature of the mixture and, in addition, give a measure of its endurance limit.

Finally, the work on confinement in a thin layer indicates that the confining pressure that would be needed in a conventional triaxial test of bituminous concrete to produce a compression strength equal to that which was developed by the mixtue when tested in a relatively thin layer equal to or greater than the unconfined compressive strength of the mixture.