Asphalt Improvements

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AN INFORMATION BULLETIN
OF THE
TRANSPORTATION TASK FORCE
OF THE

URBAN CONSORTIUM FOR TECHNOLOGY INITIATIVES

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The Urban Consortium for Technology Initiatives was formed to actively pursue technological solutions to pressing urban problems. The Urban Consortium is a coalition of 34 major urban governments, 28 cities and 6 counties, with populations over 500,000. These 34 governments represent over 20% of the nation's population and have a combined purchasing power of over $25 billion.

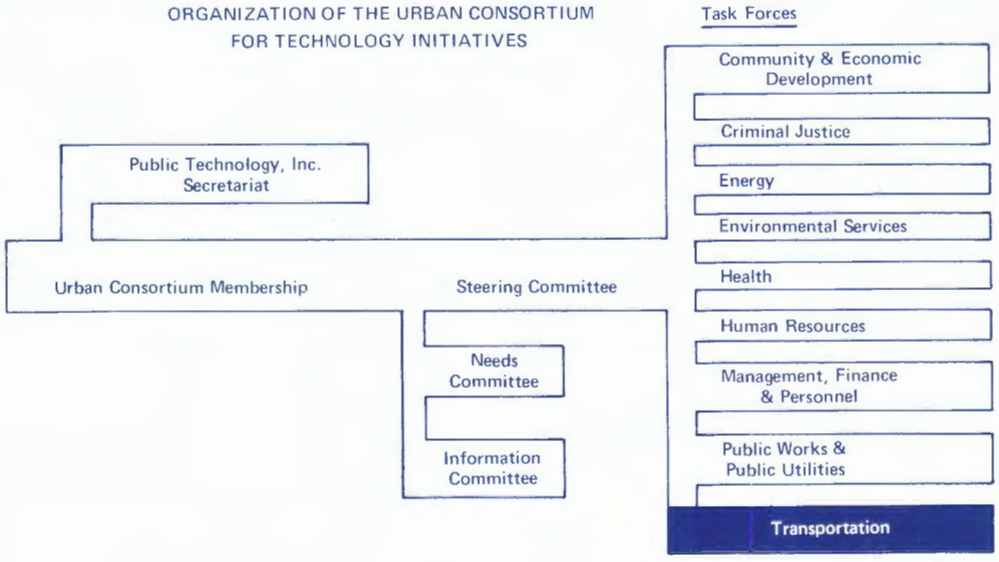
Formed in 1974, the Urban Consortium represents a unified local government market for new technologies. The Consortium is organized to encourage public and private investment to develop new products or systems which will improve delivery of local public services and provide cost-effective solutions to urban problems. The Consortium also serves as a clearing-house in the coordination and application of existing technology and information.

To achieve its goal, the Urban Consortium identifies the common needs of its members, establishes priorities, stimulates investment from federal, private and other sources and then provides on-site technical assistance to assure that solutions will be applied.

Public Technology, Inc. (PTI), a non-profit, tax-exempt, public interest organization serves as Secretariat to the Urban Consortium. PTI was established in December 1971, by The Council of State Governments, The International City Management Association, The National Association of Counties, The National Governors' Conference, The National League of Cities and The U. S. Conference of Mayors. The staff of PTI provides both technical and organizational services to the Urban Consortium and its Task Forces.

The work of the Urban Consortium for Technology Initiatives is focused through the nine Task Forces shown below. These Task Forces were formed as a result of the needs identification process used by the Consortium. An eleven member Steering Committee, whose members are chosen from among the participating jurisdictions, guides the activities of the Urban Consortium for Technology Initiatives.

ORGANIZATION OF THE URBAN CONSORTIUM FOR TECHNOLOGY INITIATIVES



Initial funding for the Urban Consortium for Technology Initiatives was obtained from the National Science Foundation/Research Applied to National Needs and from the Office of the Assitant Secretary for Systems Development and Technology, Office of the Secretary, Department of Transportation. Second-year funding has been expanded to include support from the Department of Housing and Urban Development, the Environmental Protection Agency and the Urban Mass Transportation Administration and Federal Highway Administration of the U. S. Department of Transportation.

This report is a product of the activities of the Transportation Task Force. The work has been supported by the U. S. Department of Transportation; Office of the Secretary, Urban Mass Transportation Administration and Federal Highway Administration.

ASPHALT IMPROVEMENTS

October 1976

Prepared by

PUBLIC TECHNOLOGY, INC.
1140 Connecticut Avenue, N.W.
Washington, D.C 20036

Secretariat
to the

URBAN CONSORTIUM FOR TECHNOLOGY INITIATIVES

Supported by

U.S. DEPARTMENT OF TRANSPORTATION
Washington, D.C. 20590

PREFACE

This is one of eight "Information Bulletins" developed by the Transportation Task Force of the Urban Consortium for Technology Initiatives. An "Information Bulletin" was developed for eight of the transportation need areas which were identified as the most pressing by members of the Urban Consortium. Each Bulletin provides an overview of the current issues and problems surrounding the need. These Bulletins also provide the information base from which the Transportation Task Force selects several needs for further action.

The eight needs highlighted by the "Information Bulletins" were selected in an unique process of needs identification used by the Urban Consortium. By identifying and then focusing on the priority needs of member jurisdictions, the Consortium assures that resultant research and development efforts are directly responsive to existing or anticipated local governmental problems.

Of the 1131 needs identified by Consortium members in an open-ended needs definition process, 94 dealt with transportation. These transportation needs were categorized and the duplication removed so that 58 remained. "Need Statement Abstracts" were developed for each of the 58 needs. These Abstracts provided the Transportation Task Force members with a one-page, basic definition and an overall perspective of the need. It was on the basis of these Abstracts and discussions that the Transportation Task Force developed a priority list of 10 needs which should receive further attention.

"Information Bulletins" were developed on 8 of these 10 needs. Two of the priority needs, "Preferential and Exclusive Lanes" and "Accelerated Implementation Procedures" are currently receiving action. The "Preferential and Exclusive Lanes" need is being addressed in the Manual for Planning and Implementing Priority Techniques for High Occupancy Vehicles: Executive Summary; Management Report; Technical Guide currently being prepared by the PTI staff. An User Design Committee composed of representatives from Consortium jurisdictions is guiding the preparation of this Manual. The Consortium's Steering Committee is considering the policy-oriented issues (such as streamlined grant applications) involved in "Accelerated Implementation Procedures," in consort with similar needs which have surfaced in other Consortium Task Forces. Members of the Transportation Task Force are also working with the Urban Mass Transportation Administration in ensuring that Task Force concerns are addressed in the on-going revisions to UMTA's External Operating Manual.

The needs selection process and the Abstracts from the 58 initial needs are described in detail in the first report of this series from the Transportation Task Force of the Urban Consortium for Technology Initiatives. The entire series of reports is listed below:

- Transportation Needs Summary
- Asphalt Improvements
- Institutional Framework for Integrated Transportation Planning
- Integration of Para-Transit with Conventional Transit Systems
- New Standard Bus Equipment
- Traffic Signalization Systems
- Transit System Productivity
- Transportation for Elderly and Handicapped Persons
- Transportation Planning and Impact Forecasting Tools

The support of the Research and Development Policy Analysis Division, Office of the Secretary; Federal Highway Administration; and the Urban Mass Transportation Administration of the U.S. Department of Transportation has been invaluable in the work of the Transportation Task Force of the Urban Consortium for Technology Initiatives and its staff from Public Technology, Inc. The guidance offered by the Task Force members will continue to insure that the work of the staff will meet the urgent needs which have been identified by members of the Urban Consortium for Technology Initiatives. The members of the Transportation Task Force are listed below:

Members of the Transportation Task Force continued:

Councilman Jim Self
San Jose City Council
San Jose, California

Robert Selsam
Director, Transportation Division
City Planning Commission
New York, New York

Federal Representatives

Alfonso B. Linhares
Chief, R&D Policy Analysis Division
Office of the Secretary

Robert B. Dial
Director, Planning and Methodology and Technical Support Div.
Urban Mass Transportation Administration

Milton P. Criswell
Chief, Implementation Division
Federal Highway Administration

U.S. Department of Transportation
400-7th St., S.W.
Washington, D.C. 20590

Staff Support:
Norman G. Paulhus, Jr.
R&D Policy Analysis Div.
Office of the Secretary

Secretariat Staff

Alinda C. Burke
Ellen McCarthy Casebeer
Beth Irons French
J. Robert Havlick
Gary L. Hebert
Patrice C. White

Public Technology, Inc.
1140 Connecticut Ave., N.W.
Washington, D.C. 20036
(202) 452-7700

Consultants

Fred B. Burke
William B. Hurd

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Chapter I

ISSUES AND PROBLEMS

The cost of asphalt has increased materially because of rising oil prices. This has affected the costs of street and highway paving and repair. The need has been expressed for a substitute for asphalt or for a means of reducing asphalt costs through the use of additives and recycling techniques. In addition, the focus of most street and highway departments is now on maintenance rather than new construction.

The following issues and problems concerning asphalt will be addressed in this paper:

- Costs
- Concrete: A Substitute for Asphalt
- Asphalt Additions
- Recycling Asphalt
- Air Pollution & Asphalt Removal
- Asphalt Quality
- Cut-back versus Emulsified Asphalt
- Aggregates
- Anti-skid Properties
- Productivity

Chapter II provides sources of further information on asphalt programs and research. Chapter III gives an annotated bibliography and the contact person and office for on-going projects.

COSTS

A concern with asphalt costs alone is too restrictive an approach to the basic problem of paving and repair costs given the following:

- One-tenth of the nation's road surfaces must be replaced each year. Truly significant savings could be achieved through the development of longer-lasting surfaces.

- Equipment and labor costs are much more significant elements of total paving and repair costs than the cost of materials. Improvement in techniques represents perhaps the most effective way of reducing paving and repair costs.

CONCRETE: A SUBSTITUTE FOR ASPHALT

There seems to be general agreement that the only real substiute for asphalt is concrete.[1] The major research effort in the United States has, therefore, focused upon the use of asphalt additives.

ASPHALT ADDITIVES

Considerable effort is being directed toward finding a satisfactory additive to asphalt. There are two basic approaches:

1. Improvement of the properties of asphalt.

2. Decreased use of asphalt, with appreciable change in its properties.

Public Technology, Inc. has experimented with pot-hole patching materials as a means of reducing the frequency of repairs due to freeze-thaw cycles. An ethyl vinyl acetate additive developed by the National Aeronautics & Space Administration appears promising. The ethyl vinyl acetate product also appears to be useful as a crack sealer. Tests are now being conducted in this area.

An interesting observation that has come from the PTI tests shows that the ethyl vinyl acetate product is satisfactory when properly applied. To assure comparability, the same techniques were used in applying ordinary asphalt to control pot-holes. The results showed that ordinary asphalt, when properly applied, had much better resistance to deterioration than is now commonly experienced in pavement repair.

Various other combinations, such as epoxy tar (which has been used in some airport applications because it is resistent to kerosene), have been experimented with and are judged by the Federal Highway Administration to be very expensive or hard to handle. A current research effort by the Federal Highway Administration involves the use of sulphur as an additive. Combinations with a 20 to 30 percent sulphur content show a high probability of success. A one-mile stretch of road near Lufkin, Texas which was built a year ago using normal construction procedures and the usual aggregates is now being evaluated. Another road segment improvement is being planned. In this case, lower quality aggregates and modified construction procedures will be used.

Although sulphur is not now a surplus commodity, a large surplus is expected by 1983 as a by-product of the U.S. Environmental Protection Agency's air quality regulations. The use of sulphur will, therefore, replace part of the asphalt and dispose of a waste by-product. The only

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[1] However, Canadian research over the past five years has focused on the development of using sulphur as a 100 percent replacement for asphalt. Some road construction is in place, but evaluations are not yet available.

known competing use for the expected sulphur by-product is in the production of fertilizer for developing countries.

The Federal Highway Administration suggests that the current need in this area of concern is for experimentation and demonstration, rather than for research per se. A major concern is that of achieving consistency in the asphalt mixture. Other additives under consideration include:

- Resins from sawdust, pine bark and similar sources.

  These are in the first stages of research. The results of the research and testing program are expected to be available about 1982. A major problem will be that of the transportation costs to user areas which are generally a considerable distance from the producing areas.

- Waste from wood pulp operations.

  The first research contract in this area is now being negotiated by the Federal Highway Administration. One of the major problems lies in making the product water insoluble.

- Scrap Rubber.

  The Federal Highway Administration considers this to be a technological break-through. Scrap rubber from discarded tires is granulated and mixed (25 to 30 percent) with hot asphalt to form a binder for use in seal coat operations. The binder is placed in a ¼" layer, instead of a 2" repaving coat. The product and its use are described in FHWA Implementation Package 73-1.[1]

RECYCLING ASPHALT

The recycling of asphalt is a major interest because the basic road networks are substantially complete in most places, and the principal and continuing need is for maintenance. The Federal Highway Administration believes that the basic techniques for recycling are already known and available. These include:

1. Surface recycling - recycling the top layer by first heating it, scraping it off and then relaying it in place. This is a heater-planer operation.

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[1] Federal Highway Administration. Implementation Package 73-1-Rubber-Asphalt Binder for Seal Coat Construction. Washington, D.C.: FHWA, February 1973.

2. Hot-mix recycling - picking up the old material, remelting and adding new materials, and relaying the resulting product as if it were new material. This process currently cannot meet EPA standards because of the smoke and fumes that are produced. The Federal Highway Administration believes that a solution to this problem can be readily found.

3. Cold recycling with chemical options - recycling the old pavement by scarifying, in-place pulverizing or removal for central plant crushing; adding additional aggregates and chemicals as desired; mixing; and relaying as a stabilized base. The use of some chemicals has created problems.

4. Reusing old material as a base course - this involves taking up and crushing the old material, which is then relaid and covered with a new wearing course. The base course reseals without the application of heat. The Federal Highway Administration views this process as the most promising among the recycling techniques.

AIR POLLUTION AND ASPHALT REMOVAL

The principal air pollution concern in the use of asphalt relates to the heating of the material and more specifically, to the use of the heater-planer for asphalt removal. The heater-planer method, according to Federal Highway Administration staff, is the ideal means of removing old asphalt. The problem is that it is a dirty process, creating substantial and highly visible, albeit transitory, air pollution. The use of the heater-planer has been banned in some areas -- specifically in California. While it may be anticipated that such bans will be adopted in many other places within the next five years, the new heater-planer models do not present the air quality problems of the older models.

Some experimentation has been initiated on the process of the mechanical levelling of old pavement through cutting and grinding techniques. Another process with some promise involves the use of microwave technology to disintegrate pavement developed by the National Aeronautics and Space Administration. The technology and energy trade-offs involved are currently being examined.

ASPHALT QUALITY

A developing problem is that the quality of asphalt being produced is deteriorating. The increased prices for petroleum products underlie this problem, as the economic advantages of taking off a greater proportion of the higher-grade fractions are being realized.

CUT-BACK VERSUS EMULSIFIED ASPHALT

To permit asphalt used in paving work to flow, it is customarily cut-back with kerosene or gasoline. This is now a more costly process due to increasing oil prices. In addition, the process has been banned in California because of the fumes which are given off.

The alternative is to use emulsified asphalt. This process, using water as the emulsifier, is well established and is currently used in roof construction. However, the technique is difficult to use and the state-of-the-art has not been as highly developed to-date as that of cut-back asphalt.

AGGREGATES

An area of possible cost savings for materials involves the use of waste by-products as aggregates. Some of the promising areas now under study are:

1. Use of compacted incinerator waste from which materials over 1" have been removed. This technique is being tested in Houston and Chicago.

2. Use of fused and crushed incinerator waste.

3. Use of fly-ash. Fly-ash has been used in European countries in the proportion of 60-70 percent of the aggregate material. The usual practice in the United States is a 4 percent mix. The material is usable in embankments and fields.

4. Use of bottom-ash, combined with cement and asphalt. This mixture is used in low-cost highway construction where quality is not an important consideration.

ANTI-SKID PROPERTIES

The Federal Highway Administration has been working on a 3/4" open-graded friction course which increases friction and reduces the tendency toward hydroplaning. This material is now being used to a limited extent in some western states.

Additional research is planned on the modification and treatment of aggregates to increase their anti-skid properties. The best solution appears to be an aggregate which wears unevenly to always provide a rough surface.

PRODUCTIVITY

It was suggested earlier that improvements in work techniques and methods might prove the most effective means of reducing paving and repair

costs. Very little organized effort appears to have been expended in this area, nor have the results of that effort been very successful. A major concern of studies in this area must be the effect of work rules which may have been embodied in labor agreements.

The states of New York and New Jersey have been working on the problem of productivity in road patching. The studies include materials, procedures, time and motion analysis and team size. Public Technology, Inc. has been working on a cost-effectiveness model and the development of performance specifications. The first report on this project, Street Patching Operations Decision Process, June 1976 is available from Public Technology. The results of the field tests will be published in late 1976 and will also be available from Public Technology, Inc.

Chapter II

CONTACTS AND CURRENT PROGRAMS

CONTACTS

- Federal Highway Administration
  The focal point for coordinating the dissemination of information concerning the results of the Federal Highway Administration's research and development program is that Administration's Implementation Division, headed by Milton P. Criswell. For matters concerning asphalt, contact: Robert E. Olsen, Highway Research Engineer, Implementation Division, Office of Development, Room 5208, TransPoint Building, 2100-Second Street, Southwest, Washington, D.C. 20590. (202) 426-9217.

- Public Technology, Inc.
  PTI is conducting or following research in several areas of street and highway construction and repair, including: Sylvar - a chemical material management technique for street maintenance; Dupont ploymer modified asphalts for street maintenance and bridge decking; NASA's ethyl vinyl acetate for street maintenance; a NASA microwave heater-planer operation; and Dunlop Limited's Delu-grip non-skid road surface.

- Ashpalt Institute
  The Asphalt Institute is sponsored by members of the petroleum asphalt industry to serve users and producers of asphaltic materials through engineering service, research and education. The Institute has 32 engineering offices with their main headquarters in the Asphalt Institute Building, College Park, Maryland 20740. Lists of available publications can be obtained from this address.

CURRENT PROGRAMS

The many research and development projects sponsored by the Federal Highway Administration are overviewed in the report Federally Coordinated Program of Highway Research and Development[1] published by the Offices of

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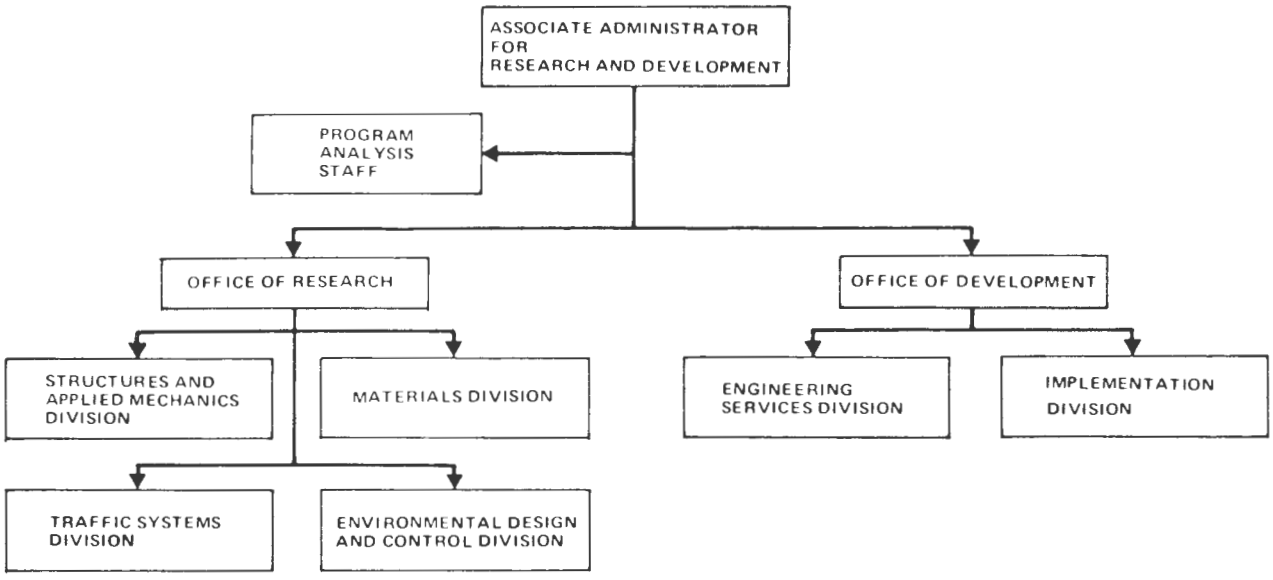
[1] U.S. Department of Transportation, Federal Highway Administration, Offices of Research and Development. Federally Coordinated Program of Highway Research and Development. Washington, D.C.: U.S. DOT, 1975.

Research and Development. Research and development are divided into the following nine major categories:

- Category 1 Improved Highway Design and Operation for Safety
- Category 2 Reduction of Traffic Congestion and Improved Operational Efficiency
- Category 3 Environmental Considerations in Highway Design, Location, Construction and Operation
- Category 4 Improved Materials Utilization and Durability
- Category 5 Improved Design to Reduce Costs, Extend Life Expectancy and Insure Structural Safety
- Category 6 Prototype Development and Implementation of Research
- Category 7 Improved Technology for Highway Maintenance
- Category 8 Demonstration Program
- Category 9 Research and Development Management Coordination

The organization of the Offices of Research and Development is shown below. Contact: Dr. G.D. Love, Associate Administrator for Research and Development, 5124 TRPT, HRD-1, 2100 Second Street, S.W., Washington, D.C. 20590. (202) 426-0714.



A demonstration project of particular interest is "Demonstration Project No. 39 - Recycling Asphalt Pavements." The project, started in May 1976, is designed to demonstrate available equipment and methods used

for recycling asphalt pavements by actual field demonstration, cost comparisons, engineering evaluations and visual media. The project will include the following.

- Hot-mix recycling
- In-place surface recycling
- Cold recycling with chemical options

Data obtained will be available to aid in establishing warrants, structural values and specifications for recycling pavements.

Additional information or a presentation of this demonstration project can be obtained from the respective state Federal Highway Administration Division Offices. The project manager is Steve Beckett, FHWA, Region 15, Demonstration Projects, 1000 N. Glebe Road, Arlington, Virginia 22201, (703) 557-0522, who can provide more information on this and other recycling projects and equipment.

Demonstration Project No. 37 - "Discarded Tires in Highway Construction" is also on-going. The objective of this project is to demonstrate the feasibility of using the rubber from discarded tires in various highway construction and maintenance operations, including:

- Seal Coats
- Joint and crack fillers
- Strain relieving interlayers

Additional information is available from state FHWA Division Offices or from U.S. Department of Transportation, Federal Highway Administration, Region 15, Demonstration Projects Division, 1000 North Glebe Road, Arlington, Virginia 22201.

Chapter III.

ANNOTATED BIBLIOGRAPHY

This bibliography was compiled primarily from sources included in the Transportation Research Information Services (TRIS) network of the U.S. Department of Transportation as edited and supplemented by the staff of Public Technology, Inc. On-going research projects which may be pertinent are also given. The title, location, project manager, sponsor and projected completion date are provided for these projects. This bibliography endeavors to give a sampling of the available literature rather than an exhaustive list of all sources of information on the topic.

GENERAL

American Association of State Highway and Transportation Officials. SPEL - Special Product Evaluation List. Washington, D.C.: Offices of Research and Development, Federal Highway Administration, USDOT, December 1975. (Rpt. No. FHWA-RD-76-91)

This document is a listing of special products which have been evaluated in some manner by state highway or transportation departments. It is intended only to provide interested governmental employees with a guide as to who has made tests on these products. The listing contains 3539 evaluations on the following subjects:

adhesives;
aggregates;
barriers, fencing and roadside structures;
bituminous materials and additives;
bituminous rejuvenators and preservative treatments;
culverts and drainage structures;
deicing chemicals;
joint sealers and fillers;
mulch and erosion controls;
patching materials;
portland cement concrete admixtures;
portland cement concrete curing materials;
portland cement concrete finishing products;
reflective crack controls;
rust passivators;

skid control systems;
soil sterilization and weed control materials;
soil treatments;
structural materials and components;
structural paints;
testing and construction equipment;
traffic marking materials;
waterproofing membranes and materials; and
miscellaneous

Federal Highway Administration, U.S.DOT. R & D Implementation Catalog. Washington, D.C.: Federal Highway Administration, September 1975.

A catalog of the publications, visual aids and computer programs available as a result of the Federal Highway Administration's R & D implementation program. Program areas are Bridge and Culver Design, Environmental, Highway Design, Highway Maintenance, Pavements, Pedestrian Safety, Hydraulics and Hydrology, Polymers, Skid, Structures, Traffic Engineering and Waste Materials.

U.S. Department of Transportation, Federal Highway Administration, Offices of Research and Development. Federally Coordinated Program of Highway Research and Development. Washington, D.C.: USDOT, 1975.

This is an annual report which presents an overview of the research and development accomplishments and significant milestones of the Federal Highway Administration's Offices of Research and Development.

STATE-OF-THE-ART

Brand, B.G. Scrap Rubber Tire Utilization in Road Dressings. Cincinnati, Ohio: National Environmental Research Center, U.S.E.P.A., 1973.

An exploration of the rubber industry has shown a wide variety of products available or easily made available from discarded automobile tires that might have potential in producing materials for use in blacktop dressing manufacture. The laboratory studies under this grant have shown that it is possible to blend finely ground tire rubber into asphalt or coal tar by either of two processes. Formulas for the nine experimental products appear in the appendix.

Carpenter, J.A. "Street Division Develops Improved Patch Truck." Public Works, Vol. 100, No. 11, November 1969, pp. 80-2.

A program aimed at developing a more efficient piece of equipment for use with hot mix asphalt patch is described. The program was intended to achieve two goals: Reduce the size of the patch crews from six men with two trucks to three men with one truck and to secure more efficient and improved workmanship. The use of a single truck containing the following was envisioned: (1) a spray mechanism capable of applying various priming agents; (2) an insulated or heated bed to maintain workability of the asphalt load from six to seven hours; (3) an air source for operating pneumatic tools and air cleaning of holes; (4) a compartment for hauling material removed from the holes; and (5) suitable compaction equipment which could readily be used without interfering with the truck operation. A training film was made of the patching operations.

Jumps, R.W. Portable Drum Dryer Plant for Maintenance. Washington, D.C.: Western Association of State Highways, Transportation Office, 1974.

Details are given of a rotary dryer mixer asphalt plant which has been successfully used under harsh climatic conditions. Mix temperatures vary between 175 and 225 degrees F depending on ambient temperatures and moisture in rock. Plant emmissions are low. Three trucks will be used to move the mini-plant to and from locations. The basic operational procedure of the drum mix process in producing asphaltic mix is described in detail.

Kari, W.J. "Replacement of Cutbacks with Emulsified Asphalt." Highway Research News #53, December 1973, pp. 21-4.

Emulsified asphalts have replaced, in large measure, the use of cutbacks in maintenance surface treatments. Most cutback construction can be done with emulsified asphalts. Current AASHO emulsified asphalt grades handle most work, either as direct substitutes or with changes in construction procedures. Emulsified primes, stockpile materials and dust palliatives have been developed and are specified by some user agencies. Information on product and construction technology must be disseminated through FHWA research implementation programs, demonstrations and state-of-the-art reports.

Lanford, S.F. Maintenance Equipment Development. Washington, D.C.: Western Association of State Highways, Transportation Office, 1974.

The following maintenance equipment ideas developed in Arizona are described: A "piggy-back" pug mill which can manufacture patching materials with emulsified asphalt; equipment which can handle reclaimed rubber-asphalt mixture to be used in filling and sealing joints and cracks in both Portland cement and asphalt pavements; a vibrating truck screen and a dump truck tailgate (a material-saving device in the application of material at various widths of asphalt surface treatments); an improvement (a spread width control) to the beason tailgate; and striping equipment and skipliner equipment.

Malish, W.R., D.E. Day and B.C. Wixson. Use of Domestic Waste Glass for Urban Paving. Rolla, Missouri: Missouri University, 1973. (NTIS PB 222 052/3)

This report summarizes research on the use of waste glass as an aggregate in asphaltic paving mixtures.

"Pavement is Half-Glass and Concrete Waste." Engineering News-Record, Vol. 189, No. 17, October 26, 1972, p. 17.

A municipal parking lot in a suburb of Detroit has been paved with a 1.5-inch bituminous binder containing crushed glass and used concrete topped by a 1-inch wearing surface without the crushed concrete. The material rolled well in 40° F temperatures and laid a good surface. It is predicted that the pavement will be stronger and have better skid resistance than ordinary bituminous concrete.

Rand, D.W. Final Evaluation of Cold Mix Surfacing Procedures. Augusta, Maine: Maine Department of Transportation, 1973.

The objectives of this project were to (1) determine what types or grades of bitumens can be mixed cold through a stabilization plant and stockpiled for later use; (2) determine what type or grade of bitumen in a mixture can be effectively handled on the roadway with graders; (3) determine the quantity of material that can be most effectively placed with regard to equipment and quantity of material needed to properly smooth a low class type paved road; (4) determine the total cost per cubic yard of mixture when compared to a cubic yard when mixed on the roadway in the conventional manner with graders; and (5) determine if it is necessary to "task" an existing road prior to placing premixed material.

"Reprocessed Tires to Extend Pavement Life." Roads and Streets, Vol. 115, No. 7, July 1972, p. 31.

A mixture of 25 percent granulated rubber recycled from old tires and 75 percent paving asphalt will be used on a 7.5 mile stretch of highway in a research effort designed to prolong the life of existing pavements. The resurfacing mix will also feature a lightweight synthetic aggregate which will not break windshields. Previous experiments using an emulsifier which includes 5 percent liquid latex and may be applied cold have given good results in binding severely cracked paving. Another advantage in the use of these materials is that their moisture-proof quality will extend the life of the pavement.

Sargent, H.M. "Chemical Stabilization Permits Upgrading County Highways." Public Works, Vol. 105, No. 10, October 1974, pp 90-2.

This article describes a reclamation process used for bituminous surfaced roadways in Elkhart County, Indiana. First, the existing roadway was scarified to break down the pavement slab to smaller rubble. Then a water solution of SA-1, a chemical stabilizer, was applied. About 30 minutes later the bituminous rubble started to soften, crumble and separate. The material was pulverized to accelerate the breakdown process and windrowed to one side of the road to allow treatment of clay areas with clapak-claset, clay subbase stabilizers. The windrowed material was kept pliable by applying water to it during this process. Finally, the windrowed material was bladed and spread uniformly over the stabilized clay base. The surface was then fine-graded, re-rolled and compacted until the water had evaporated. A highly viscous bitumen was used to penetrate and prime the surface, which was then chip-sealed and left until the following year when it was again chip-sealed. There has been negligible maintenance done on the roadway since the resurfacing which was done in 1971-72. The process takes one to three days and costs are around $7,000 dollars for personnel, equipment and chemicals.

Scrimsher, T., M.H. Johnson and G.B. Sherman. Cold Asphalt Overlay. California: California Division of Highways, 1972. (NTIS PB 219 233)

This report discusses the construction and first year's performance of two cold asphalt emulsion mixtures placed in an 1-inch overlay on an existing asphalt concrete pavement. This overlay is the first project in a study to determine if cold mixed asphalt concrete can reduce particulate and aerosol emissions and at the same time provide a durable

asphalt concrete pavement. The particulate and aerosol emissions of the cold mix were less than hot mix operations. However, pavement performance has not been equivalent to adjacent hot mix pavement overlays.

"'Skinny-Mix' Broadens Cost Range of Overlaying Aging Pavements". Rural and Urban Roads, Vol. 11, No. 1, January 1973, pp 20-2.

A detailed procedural description of this resurfacing is provided. The method costs about $4,100 per two-lane mile. Preliminary discussion focuses on the need to improve and maintain existing highways, the need to waterproof, the overlay method, airvoids and grades.

"Spray Bar Practices." Better Roads, Vol. 43, No. 4, April 1973, pp 41-2.

Spray bar practices in Michigan, Ohio and Kansas are described. The pavement is swept before application of the liquid asphalt. Weather conditions such as wet weather and temperatures below 60 degrees are recognized as limiting factors. Brooming may (Michigan) or may not (Ohio, Kansas) be done after aggregate lay down. The bar is test sprayed before starting a run. The cost of surface sealing per square yard is $0.25-.40 cents in Michigan, $0.11 in Ohio, and $0.08 in Kansas.

Stokely and McDonald. "Hot Rubber Asphalt Seal Coats to Cure Cracking Streets." Public Works, Vol. 103, No. 7, July 1972, pp 46-8.

A 1966 article by McDonald reported several small-scale applications of an approach to alligatoring in which high percentages of rubber were used in asphalt to provide a cementing agent for chip seal coats or resurfacing of asphalt pavements over elastic subgrades or bases. The innovation produced a highly elastic membrane tolerating high pavement deflections without cracking. The present article describes large-scale application of the method to the resurfacing of many miles of older streets in Phoenix, Arizona.

Swilley, H.D. and B.M. Galloway. Lightweight Hot-Mix, Cold-Laid Maintenance Mixture. Texas: Texas Transportation Institute, 1972.

Laboratory and field properties of lightweight hot-mix, cold-laid maintenance mixtures are presented. The information indicates that conventional mixing, storage and placing operations can be used to prepare and place these mixtures. Adequate and prolonged skid resistance is indicated for properly designed mixtures.

RECYCLING

Cox, D.O. "Recycled Material for Aggregate Base." Highway Focus, Vol. 4, No. 3, April 1972, pp 1-7.

The material is supplied by a crushing plant on the project site which crushes Portland cement concrete rubble and asphalt concrete (AC) rubble. After initial crushing, the rubble (which consists of chunks of concrete and AC from demolished structures, parking lots and roads) is screened. All material not passing the 1-inch screen is carried off by a conveyor belt to be recycled through the cone crusher. The finished product must meet specifications of either class 2 or 3. Typical test results are tabulated. Problems encountered with the sand equivalent test are discussed. Features pointed up in the cost analysis are reported. Although accurate equipment costs are not available, other informative cost factors are presented.

Dunning, R.L. Feasibility Study of the Marketability of the RMI, Thermo-matic Plant for Recycling Pavements. Anaheim, California: Dunning, 1974.

In this assessment of the marketability of a newly developed mixing plant through which discarded asphalt concrete may be recycled, consideration is given to the economic, technological, environmental and marketing aspects. This recycle operation has the advantages of lower cost, reduction of the use of scarce natural resources and an improvement in the quality of the environment. There are also indications that a recycled pavement may perform better than one made of virgin asphalt.

Federal Highway Administration, Offices of Research and Development. Implementation Package 73-1; Rubber-Asphalt Binder for Seal Coat Construction. Washington, D.C.: Federal Highway Administration, U.S. Dept. of Transportation, February 1973. (NTIS PB 219 012)

This paper describes the development and use of a rubber-asphalt binder for seal coat construction. Whereas rubber has been added to asphalt in low percentages (3 to 5 percent) in the past, this binder uses high percentage (25 to 30 percent) additions of granulated tread rubber reclaimed from discarded automobile tires.

The granulated rubber is mixed with hot asphalt to form a tough and elastic binder with less susceptibility to temperature changes. It has been used very successfully in seal coat construction for maintenance operations in the city of Phoenix, Arizona, for several years and has

been especially successful in overlaying pavements that exhibit severe fatigue or "alligator" cracking.

This paper describes the construction procedure used in Phoenix, and includes a recommended specification for seal coat construction using the rubber-asphalt composition as the binder.

Klucker, R.H. "Pavement-Salvaging Experience on the Pennsylvania Turnpike," Highway Research Record #327. Washington, D.C.: Highway Research Board, 1970, pp 18-24.

Reports the experience of the Pennsylvania Turnpike Commission in salvaging concrete pavement with bituminous overlays and in salvaging bituminous pavement with either a bituminous overlay or a surface treatment. Design features, specification requirements, construction operations and problem areas are briefly outlined.

Lindley, B.R. Cold Recycling of Asphalt Concrete Pavement. Taylor County, Texas: State Department of Highways and Public Transportation, October 1975. (Rpt. No. 613-1)

The purpose of the experiment reported here was to develop a procedure to use existing asphalt pavement by crushing, adding additional asphalt and a softening agent to the crushed mixture and replacing without the use of heating equipment. There were six main objectives to be tested on the development of this system:

1. Determine the possibility of crushing old hot-mix in place,

2. Provide an asphalt softening agent capable of re-establishing specified qualities of the old asphalt,

3. Determine the best type of asphalt to be used as an additive,

4. Establish a sequence of work and the type equipment needed for this type project,

5. Compare cost with other standard reconstruction operations,

6. And, study strength comparisons with other hot-mix and base courses.

The first four main points of interest were proven during the course of this project. The cost of a completely new process can not easily be compared with that of a process that has been used for years. An analysis of the complete project reveals that using certain techniques which were

developed and improved upon during the course of the experiment could reduce the cost by approximately fifteen percent. The strength and durability of the mix will be determined by time and performance under traffic.

Marek, C.R., B.M. Galloway and R.E. Long. "Look at Processed Rubble-It's a Valuable Source of Aggregates." Roads and Streets, Vol. 114, No. 9, September 1971, pp 82-5.

Recycling pavement and structural concrete rubble from obsolete highways, driveways, curbs, gutters, sidewalks, piers, abutments and culverts is very economical. How the Texas Highway Department has demonstrated the technical and economic feasibility of transforming solid waste into a useful building material for a highway is described. Problems are discussed for (1) processing, (2) rubble preparation, (3) embankment preparation, (4) asphalt-stabilized base, (5) surface mixtures and (6) economics.

Morris, Gene R., Arizona Department of Transportation. "Asphalt-Rubber Membranes-Development, Use, Potential." Paper presented to the 1975 Conference of the Rubber Reclaimers Association, Cleveland, Ohio.

Provides statistical information on the experiences of the Arizona Department of Transportation in their work with asphalt rubber seal coats in varying climatic conditions. It has been found that such seal coats are useful as stress absorbing membranes; are capable of attenuating pavement structure stresses; in providing a moisture barrier; as well as for many other, as yet unexplored, projects.

"Old Asphalt Can Be Valuable Raw Material." Roads and Streets, Vol. 116, No. 6, June 1974, pp 105-106.

A process has been invented to recycle and reuse asphalt rubble. A petroleum based softening agent and ½ to 2 percent additive virgin asphalt are essential ingredients. Supplies of new aggregates are usually needed to fill gradations; but savings of up to 35% are apparent with the prototype.

The roadrunner is designed around a counterflow, oil-fired, inclined drum dryer. A conveyor system brings crushed and screened rubble and any additional new aggregates to this bin. An important feature of the design is that it produces a smoke-and fume-free effluent. The inventor has been making a series of tests to determine penetration, stability and aggregate gradation of the recycled asphalt. Results indicate quality identical to that of asphalt mixes made with virgin materials. Mix

design of the recycled materials can be better than that of the original by correcting deficiencies.

Proudy, Henry, Galen Gregory and James Hodge. Recycled Asphalt Concrete. (Implementation Package 75-5) Washington, D.C.: Office of Development, Federal Highway Administration, U.S. Dept. of Transportation, September 1975.

This report describes the equipment, material and procedures used to reconstruct the right lane and shoulder of a badly deteriorated one-mile section of an interstate highway in southern Nevada by recycling the original asphalt, 4-inch pavement. Additional asphalt and rejuvenating materials were added to increase penetration of asphalt and to meet mix design.

Crushed material was remelted in a contractor-designed and patented rotating heat exhanger having a series of flues to carry hot gases through the tumbling mass; emissions were quite minimal. Suggested specifications and unit cost information are included.

"Recycled Rubble Saves Contractors Money." Roads and Streets, Vol. 116, No. 4, April 1973, pp 80-3.

The feasibility of using recycling methods without environmental distrubance in a crowded metropolitan area was demonstrated by use of a portable plant which produced 10,000 CU YD of 1.5 - in. class aggregate base from 14,000 tons of concrete and asphalt. The crushed material contained adequate fines and small amounts of unhydrated cement. This aided compaction when mixed with water and was approved by state inspectors for subbase. When processing such material as street paving, curbs and asphalt, the continuous operation of the two-stage crushing system produced approximately 350 TPH. The drying of material, the removal of trash and steel and the problem of soft asphalt in warm weather make it difficult to maintain continuous operation.

The problems encountered in the practice of this operation are discussed. The availability of quality concrete or asphalt raw material is important as this is a factor in the loss of time caused by excess steel and refuse. Frequent moving results in high maintenance costs. Attention must be paid to the abatement of noise and air pollution.

"Recycling Cement Stabilized Base Course." Paving Forum, June 1973, p 4-7.

A project is described which involved the removal, recrushing and relaying of the bituminous surface and the cement stablized base course, and the reconstruction of a

new 3-inch bituminous pavement. The relayed material was primed with an MC-70 and resulted in an extremely stable base course under local traffic and the contractor's equipment. A true evaluation of the performance of the recycled base will require the test of time.

Tishoker, K.J. Re-cycled Asphalt Concrete Research Project for McCarran International. Las Vegas, Nevada: McCarran International Airport, 1974.

A test section was paved with re-cycled asphalt concrete to determine if it could meet all the Federal Aviation Administration specifications for P-401 bituminous surface course. The asphalt concrete was obtained from a discarded pile of old asphalt concrete torn up from a runway. Many laboratory and field tests were run. A review of the test data indicates that the use of recycled asphalt can meet all of the Federal Aviation Administration specifications for P-401 bituminous surface course. Visual inspection of the test section shows that the pavement is virtually indistinguishable from that of original asphalt pavement.

Transportation Research Board. Bituminous Emulsion for Highway Pavements: Synthesis of Highway Practice 30. Washington, D.C.: Transportation Research Board, 1976.

An up-to-date, comprehensive report on the use of emulsions in highway pavements. Emulsion asphalts have been available for more than 70 years, but their use has not been extensive or widespread. This has been due in part to the absence of specific design information and construction specificatiosn and instruction. The report addresses each of these areas.

HEATER-PLANER REGULATIONS

Howard Needles, Tammen and Bergendoff. Effects of Air Pollution Regulations on Highway Construction and Maintenance. NCHRP Research Project 20-12. Research has been completed, and the report is in the NCHRP editorial and publication process.

This research evaluates the effect of air pollution regulations for fugitive particulates and hydrocarbons on the highway construction and maintenance industry. Research was limited to the on-site construction process rather than off-site materials processing.

A survey of air pollution control officials and highway maintenance and construction officials was conducted. This survey determined the monitoring procedures used by the industry to identify possible violations, and tabulated

those activities likely to produce illegal emissions. Mitigation methods favored by construction are also listed.

A testing program for fugitive particulates generated by highway construction was performed to measure ambient air quality concentrations. Also a hydrocarbon testing program evaluated the emissions from both the asphalt paving operation and cutback asphalt application during highway construction. Essentially no violations of the ambient air quality standards are attributable to highway paving and priming.

SKID RESISTANCE

Arena, P.J. Field Evaluation of Skid Resistant Surfaces. Baton Rouge, Louisiana: Louisiana Dept. of Highways, no date. (NTIS PB 199 357)

This project was undertaken to establish a thin bituminous surface course that would possess good skid resistant qualities and be both economical and durable. Eleven, duplicate 1000 foot test sections were constructed on a roadway that carried approximately 9700 vehicles per day. These test sections contained four different types of bituminous mixtures (asphaltic concrete, sand asphalt, plant mix seals and slurry seal). The aggregates used consisted of crushed gravel, slag, expanded clay and granite. The evaluation of the test sections was based primarily on the skid-resistant qualities of the mixtures, with consideration given to the ease of construction and finished riding surface.

Bannister, A. and D. Walker. "Epoxy Resin-Pulverized Fuel Ash Mixtures." Journal of the Institute of Municipal Engineers, Vol. 97, No. 10, October 1970, pp 268-74.

The addition of pulverized fuel ash (PFA) and sand to epoxy resin can produce a mortar of concrete which possesses strengths in excess of those attributable to normal Portland cement concrete and which can be used to form structural joints and sections. Resin mortar can be used as a thin coating in repairing curbs, slabs or vertical faces. Tests on resin PFA mixtures show that, as with bituminous mixtures, the coarse texture and fine-scale harshness provided by the aggregate are important in skid resistance. It is possible that asphaltic mixtures could be developed using PFA/epoxy resin mortars, which would be durable, polish-resistant and skid-resistant. Such mixes could provide a method of retexturing concrete road surfaces.

Kearney, E.J., G.W. McAlpin and W.C. Burnett. "Development of Specification for Skid-Resistant Asphalt Concrete," Highway Research Record #396. Washington, D.C.: Highway Research Board, 1972, pp 12-20.

Ten years of research in New York State on the skid resistance of asphalt pavements are summarized. Specifications have been written to require aggregates not meeting state requirements to be upgraded by blending them with 20 percent noncarbonate stone.

Maupin, G.W. "Sprinkle Treatment Increases Highway Skid Resistance." Civil Engineering ASCE, Vol. 42, No. 2, February 1972, p 51.

The development of a sprinkle treatment for highway pavements is the most recent research attempt at finding ways to use limestone aggregates without sacrificing pavement skid resistance. Experience with testing in Virginia indicates the method can be used to provide economical skid-resistant pavements in areas where non-polishing aggregates are not available.

Moekenjie, A.J. "Spray Grip Anti-Skid Surfacing Materials," Highway Research Record #376. Washington, D.C.: Highway Research Board, 1971, pp 61-2.

The use of spray grip anti-skid surfacing materials is a new form of surface treatment that has proved extremely successful on accident-prone spot locations where there has been a high frequency of wet-road skidding accidents. In London, where 41 sites were treated, rear-end collisions were reduced by 73 percent during a 2-year period. The key factors contributing to the performance of spray grip materials are binder, aggregate and application process. Detailed descriptions of these key factors are given.

Smith, R.W. and S.R. Spelman. Design of Open-Graded Asphalt Friction Courses. Washington, D.C.: Federal Highway Administration, 1974. (NTIS PB 277 479/AS)

Efforts to improve pavement skid resistance have shown the advantages of using open-graded asphalt paving mixtures. Extensive implementation of these mixtures has been hampered due to some deficiencies observed in service performance. A new design method has been developed which purports to satisfy the highway industry. The described method is relatively new, but has been used successfully on several FHWA, R&D demonstration projects. It is believed that the proposed method provides technological improvements over other existing methods and its use is recommended for immediate experimental application.

Transportation Research Board. "Wear-Resistant and Skid-Resistant Highway Pavement Surfaces," Highway Research Board NCHRP Digest #61. Washington, D.C.: Transportation Research Board, 1974.

Literature was extensively reviewed and a method is described for classifying pavement systems with regard to wear and skid resistance and tentative performance criteria. Recommendations are made for use of the systems judged to be most suitable for practical application. An annotated bibliography of more than 500 items on the subject is presented and recommendations are made for more innovative pavement systems. The findings of the investigation are outlined and a brief description is given of ten systems selected as suitable for immediate practical application. The selection of an optimal system for a specific location is discussed.

U.S. Federal Highway Administration. Open Graded Plant Mix Slabs. Washington, D.C.: FHWA, 1973.

Open graded plant mix seals presently offer the best potential of any bituminous surface for providing as high a level of skid resistance throughout the life of the pavement as is economically feasible. A mix design must be used which allows the maximum effectiveness of the skid properties of the aggregate to be developed. These surfaces also result in much less splash and spray from truck tires, are quieter and present a smoother riding surface. This paper is a summary of state experience and practices, and contains a recommended mix design.