

NCHRP

National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

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These Digests are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may do so through contact with the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

Responsible Staff Engineer: Scott A. Sabol

Continuing Project to Synthesize Information on Highway Problems

A staff digest of the progress and status of NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems," for which the Transportation Research Board is the agency conducting the research. The Principal Investigators responsible for the project are Sally D. Liff, Manager, Synthesis Studies; Stephen F. Maher, P.E., and Donna L. Vlasak, Senior Program Officers, serving under the Studies and Information Services Division of the Board.

INTRODUCTION

Administrators, practicing engineers, and researchers continually face highway problems on which much information already exists, either in documented form or in terms of undocumented experience and practice. Unfortunately, this information is often fragmented, scattered, and undervalued. Often it is unknown to the person normally responsible for making decisions related to the topic. As a consequence, full knowledge of what has been learned about a problem is frequently not brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There exists a vast storehouse of information relating to nearly every subject of concern to highway administrators and engineers. Much of it resulted from research and much from successful application of the ideas of practitioners faced with problems in their day-to-day work. Because there has been no systematic means for bringing such useful information together and making it available to the entire highway community, the American Association of State Highway and Transportation Officials has, through the mechanism of the National Cooperative Highway Research Program, authorized the Transportation Research Board to undertake a continuing study, NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems." This study is intended to search out and synthesize useful knowledge from all possible sources and to prepare documented reports on current practices in the subject areas of concern. Reports

from this endeavor constitute an NCHRP report series, Synthesis of Highway Practice, that collects and assembles the various forms of information into single concise documents pertaining to specific highway problems or sets of closely related problems.

THE SYNTHESIS PROGRAM

This synthesis series attempts to report on the various practices, making some recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems. The

Suggestions for synthesis topics may be sent to the NCHRP Program Director at any time (see address on back). Topics suggested must be accompanied by a brief scope statement or discussion of the problem (a paragraph or two). Suggestions for updates of published syntheses are also welcome.

Interested in writing a synthesis? For details, contact Sally D. Liff, Stephen F. Maher, P.E., or Donna L. Vlasak at 202-334-3244, 3245, or 2974, respectively.

extent to which they are used in this fashion will be tempered by the breadth of the user's knowledge in the particular problem area.

To develop these syntheses in a comprehensive manner and to ensure inclusion of significant knowledge, the Transportation Research Board analyzes available information assembled from numerous sources, including state highway and transportation departments. A panel of experts in the subject area is established to guide the researchers in organizing and evaluating the data collected on each topic and to review the synthesis report.

For each topic the project objectives are (1) to locate and assemble documented information; (2) to learn what practice has been used for solving or alleviating the problems; (3) to identify all ongoing research; (4) to learn what problems remain largely unsolved; (5) to organize, evaluate, and document the useful information that is acquired; and (6) to evaluate the effectiveness of the synthesis after it has been in the hands of its users for a period of time.

Each synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that which is now at hand; eventually the synthesis may need to be updated or redone. The readers and users of the syntheses are in the best position to know when this has occurred. Whenever you believe that a synthesis should be updated, it would be appreciated if you would write to TRB (address on back) and let us know.

Studies in Progress and Planned for 1996

Work is currently under way on the topics listed in Table 1. Topics selected for the current program are listed in Table 2. Questions on these topics should be addressed to the principal project investigators, Sally D. Liff, Stephen F. Maher, P.E., or Donna L. Vlasak, who can be reached at (202) 334-3244, 3245, or 2974, respectively.

Selection of Topics

NCHRP Project Committee SP20-5 meets each year to select topics for study using funds from the upcoming fiscal year. The membership of this committee is given in Table 3. Current funding allows for initiation of about 12 syntheses per year. This number, plus some alternative topics, is selected by the committee at the annual project meeting.

The following factors are considered in the selection process for synthesis topics:

- The problem should be widespread enough to generate broad interest in the synthesis.
- The problem should be timely and critical with respect to economic impact, safety, or social impact.
- The problem is appropriate if current practice is nonuniform or inconsistent from agency to agency, or if the validity of some practices appears to be questionable.

- The quality and quantity of useful available information should indicate a need to organize and compress that which has already been learned and written on the topic.
- The topic should not be one where ongoing research or other activities in progress might be expected to render the synthesis obsolete shortly after completion.

Each year many more topics are suggested for the committee's consideration than can be programmed for study in Project 20-5. Nevertheless, the continued success of this project depends on a constant supply of worthy synthesis topics. The interest of those who have recommended topics is sincerely appreciated, and they are urged to continue. Candidate topics are suggested by members of the committee and by a variety of other sources, including state highway and transportation department personnel; FHWA; AASHTO; and TRB committees; and other practitioners and researchers.

Available Publications

The Syntheses of Highway Practice that have been completed under this project are listed in Table 4. Four Research Results Digests on topics studied under the project are also listed. Copies of these Syntheses and Digests can be obtained from the Publications Office, Transportation Research Board, 2101 Constitution Avenue N.W., Washington, D.C. 20418 or by calling (202) 334-3214.

Index of Topic Subjects

Table 5 is an index to published syntheses and digests and topics under study, as well as those expected to be started through 1996.

Conduct of the Studies

Throughout the year, following the project committee's selection of topics, studies are initiated in the order of priority assigned by the committee. A panel consisting of practitioners and researchers is formed for each topic. At its first meeting, this topic panel thoroughly discusses the topic, refines the scope, suggests sources of information, and identifies and discusses potential topic consultants.

Following this meeting, an agreement is negotiated with a consultant to gather information on the topic, synthesize it, and draft a report. Typically, the agreement covers about 50 workdays over a period of about one year. Information gathering and preparation of the first draft of the synthesis report usually take from 6 to 9 months. This draft is reviewed by the topic panel with the consultant at the second panel meeting. A revised draft is then prepared by the author and reviewed by the topic panel. Subsequent drafts and meetings are scheduled if needed, although this rarely occurs.

After the topic panel is substantially satisfied with the report, a final draft is sent to the members of NCHRP Project Committee SP20-5 for their approval. At the same time, members of the topic panel have their last chance to review the report, which is usually published as an NCHRP Synthesis of Highway Practice.

Table 1
TOPICS BEING STUDIED

No.	Topic	No.	Topic
22-12	Truck Operating Characteristics	26-12	Alternate Methods of Corrosion Protection for Exposed Bridge Steel Surfaces
23-11	Changeable Message Signs	27-01	Trenchless Construction of Conduits Beneath Roadways
25-04	Guardrail and Median Barrier Crashworthiness	27-02	Criteria for Routing of Hazardous Materials
25-07	Pavement Subsurface Drainage Systems	27-03	Stability of Existing Subgrades During Interstate Pavement Rehabilitation to Improve Constructibility
25-11	Toll Plaza Design	27-04	Methods of Increasing Live Load Capacity of Existing Highway Bridges
25-12	Operational Management of the Transportation System	27-05	Methods for State Construction and Materials Acceptance
25-15	Performance Measurement in Departments of Transportation	27-06	Outsourcing of State Highway Facilities and Services
25-16	Dynamic Effects of Pile Installations on Adjacent Structures	27-07	Methods for Overcoming Product Liability to Achieve Highway Innovations
25-21	Service Life of Drainage Pipe	27-08	Thin-Surfaced Pavements
26-03	Methods for Household Travel Surveys	27-09	Methods for Capital Programming and Project Scheduling
26-04	Highway-Rail Crossing Surfaces	27-10	Response of Small Urbanized Area MPOs to ISTEA
26-05	Relationship Between Pavement Surface Texture and Highway Traffic Noise	27-11	Traffic Signal Control Systems Maintenance Management Practices
26-06	Land Development Regulations that Promote Access Management	27-12	Road User and Mitigation Costs in Highway Pavement Projects
26-07	Application of Full-Scale Accelerated Pavement Testing	27-16	Status and Application of GPS Satellite Positioning for Departments of Transportation
26-08	Ground Penetrating Radar (GPR) for Evaluating Subsurface Conditions for Transportation Facilities		
26-09	Evaluation of Effectiveness and Impact of Training		
26-10	Settlement of Bridge Approaches		
26-11	Transportation Development Process		

Table 2
SYNTHESIS TOPICS SELECTED FOR THE FY 1996 PROGRAM

No.	Topic	No.	Topic
28-01	Management of Highway and Street Related Environmental Issues	28-09	Use of Traffic Circles in the United States
28-02	Geotechnical Aspects of Load and Resistance Factor Design (LRFD)	28-10	Traffic Management Center Functions
28-03	Project Development Methodologies for Urban Freeway Redesign and Reconstruction	28-11	Innovative Tolling Practices
28-04	Lead-Based Paint Removal for Steel Highway Bridges	28-12	Traffic Signal Preemption at Highway-Rail Intersections
28-05	Dynamic Impact Factors for Bridges		<i>Alternate Topics</i>
28-06	Methods to Achieve Rut Resistant Asphalt Pavements	28-13	Numerical Modeling Techniques in Geotechnical Engineering
28-07	Submittal of Bids and Bid Documents in Electronic Form	28-14	Impact of Narrow Median Widths on Commercial Vehicles
28-08	Guidelines and Standards for the Preservation of Historic Highway Bridges	28-15	Methods of Reducing Traffic Speed Upon Approaching Built-Up Areas

Table 3
NCHRP PROJECT COMMITTEE SP20-5

Chairman Jon P. Underwood Texas Department of Transportation	
Kenneth C. Afferton New Jersey Department of Transportation (Retired)	David H. Pope Wyoming Department of Transportation
Gerald L. Eller Federal Highway Administration	Earl C. Shirley California Department of Transportation (Retired)
John J. Henry Pennsylvania Transportation Institute	J. Richard Young, Jr. Mississippi Department of Transportation
Gloria J. Jeff Federal Highway Administration	<i>Liaisons</i>
C. Ian MacGillivray Iowa Department of Transportation	Richard A. McComb Federal Highway Administration
Eugene E. Ofstead Minnesota Department of Transportation	Robert E. Spicher Transportation Research Board

Table 4
COMPLETED SYNTHESSES

No. Title, Pages, Price	No. Title, Pages, Price
1. Traffic Control for Freeway Maintenance (1969) 47 pp., \$2.20	47. Effect of Weather on Highway Construction (1978) 29 pp., \$3.20
2. Bridge Approach Design and Construction Practices (1969) 30 pp. (microfiche)*	48. Priority Programming and Project Selection (1978) 31 pp. (out of print)
3. Traffic-Safe and Hydraulically Efficient Drainage Practice (1969) 38 pp. (microfiche)*	49. Open-Graded Friction Courses for Highways (1978) 50 pp., \$4.00
4. Concrete Bridge Deck Durability (1970) 28 pp. (microfiche)* (supplemented by Synthesis 57)	50. Durability of Drainage Pipe (1978) 37 pp. (microfiche)*
5. Scour at Bridge Waterways (1970) 37 pp. (microfiche)*	51. Construction Contract Staffing (1978) 62 pp., \$6.00
6. Principles of Project Scheduling and Monitoring (1970) 43 pp. (microfiche)*	52. Management and Selection Systems for Highway Maintenance Equipment (1978) 17 pp., \$4.40
7. Motorist Aid Systems (1971) 28 pp., \$2.40	53. Precast Concrete Elements for Transportation Facilities (1978) 48 pp., \$5.60
8. Construction of Embankments (1971) 38 pp. (microfiche)*	54. Recycling Materials for Highways (1978) 53 pp. (microfiche)*
9. Pavement Rehabilitation—Materials and Techniques (1972) 41 pp. (out of print)	55. Storage and Retrieval Systems for Highway and Transportation Data (1978) 30 pp., \$4.80
10. Recruiting, Training, and Retaining Maintenance and Equipment Personnel (1972) 35 pp. (microfiche)*	56. Joint-Related Distress in PCC Pavement—Cause, Prevention, and Rehabilitation (1979) 36 pp., \$5.20
11. Development of Management Capability (1972) 50 pp. (out of print)	57. Durability of Concrete Bridge Decks (1979) 61 pp. (microfiche)* (supplements Synthesis 4)
12. Telecommunications Systems for Highway Administration and Operations (1972) 39 pp., \$2.80 (superseded by Synthesis 165)	58. Consequences of Deferred Maintenance (1979) 24 pp., \$4.40
13. Radio Spectrum Frequency Management (1972) 32 pp., \$2.80	59. Relationship of Asphalt Cement Properties to Pavement Durability (1979) 43 pp., \$5.60
14. Skid Resistance (1972) 66 pp. (microfiche)*	60. Failure and Repair of Continuously Reinforced Concrete Pavement (1979) 42 pp., \$5.60
15. Statewide Transportation Planning—Needs and Requirements (1973) 41 pp. (microfiche)* (superseded by Synthesis 95)	61. Changeable Message Signs (1979) 37 pp., \$5.60
16. Continuously Reinforced Concrete Pavement (1973) 23 pp., \$2.80	62. Potential State Resources for Financing Transportation Programs (1979) 34 pp., \$5.20
17. Pavement Traffic Marking—Materials and Application Affecting Serviceability (1973) 44 pp., \$3.60 (superseded by Synthesis 138)	63. Design and Use of Highway Shoulders (1979) 26 pp., \$4.80
18. Erosion Control on Highway Construction (1973) 52 pp. (microfiche)*	64. Bituminous Patching Mixtures (1979) 26 pp., \$4.80
19. Design, Construction, and Maintenance of PCC Pavement Joints (1973) 40 pp. (out of print)	65. Quality Assurance (1979) 42 pp., \$5.60
20. Rest Areas (1973) 38 pp., \$3.60	66. Glare Screen Guidelines (1979) 17 pp., \$4.40
21. Highway Location Reference Methods (1974) 30 pp., \$3.20	67. Bridge Drainage Systems (1979) 44 pp., \$5.60
22. Maintenance Management of Traffic Signal Equipment and Systems (1974) 41 pp. (microfiche)* (superseded by Synthesis 114)	68. Motor Vehicle Size and Weight Regulation, Enforcement, and Permit Operations (1980) 45 pp., \$6.00
23. Getting Research Findings Into Practice (1974) 24 pp., \$3.20	69. Bus Route and Schedule Planning Guidelines (1980) 99 pp., \$8.00
24. Minimizing Deicing Chemical Use (1974) 58 pp. (microfiche)*	70. Design of Sedimentation Basins (1980) 53 pp., \$6.80
25. Reconditioning High-Volume Freeways in Urban Areas (1974) 56 pp., \$4.00	71. Direction Finding from Arterials to Destinations (1980) 50 pp., \$6.40
26. Roadway Design in Seasonal Frost Areas (1975) 104 pp. (microfiche)*	72. Transportation Needs Studies and Financial Constraints (1980) 54 pp., \$6.40
27. PCC Pavements for Low-Volume Roads and City Streets (1975) 31 pp. (microfiche)*	73. Alternative Work Schedules: Impacts on Transportation (1980) 54 pp., \$6.80
28. Partial-Lane Pavement Widening (1975) 30 pp., \$3.20	74. State Transit-Management Assistance to Local Communities (1980) 34 pp., \$6.00
29. Treatment of Soft Foundations for Embankments (1975) 25 pp., \$3.20 (supplemented by Synthesis 147)	75. Transit Boards—Composition, Roles, and Procedures (1981) 24 pp., \$6.20
30. Bituminous Emulsions for Highway Pavements (1975) 76 pp. (microfiche)*	76. Collection and Use of Pavement Condition Data (1981) 74 pp., \$8.00
31. Highway Tunnel Operations (1975) 29 pp., \$3.20	77. Evaluation of Pavement Maintenance Strategies (1981) 56 pp., \$7.40
32. Effects of Studded Tires (1975) 46 pp., \$4.00	78. Value Engineering in Preconstruction and Construction (1981) 23 pp., \$6.40
33. Acquisition and Use of Geotechnical Information (1976) 40 pp., \$4.00	79. Contract Time Determination (1981) 45 pp., \$7.20
34. Policies for Accommodation of Utilities on Highway Rights of Way (1976) 22 pp. (microfiche)*	80. Formulating and Justifying Highway Maintenance Budgets (1981) 49 pp., \$7.20
35. Design and Control of Freeway Off-Ramp Terminals (1976) 61 pp., \$4.40	81. Experiences in Transportation System Management (1981) 88 pp., \$8.40
36. Instrumentation and Equipment for Testing Highway Materials, Products, and Performance (1976) 70 pp., \$4.80	82. Criteria for Evaluation of Truck Weight Enforcement Programs (1981) 74 pp., \$7.20
37. Lime-Fly Ash-Stabilized Bases and Subbases (1976) 66 pp. (microfiche)*	83. Bus Transit Accessibility for the Handicapped in Urban Areas (1981) 73 pp., \$7.60
38. Statistically Oriented End-Result Specifications (1976) 40 pp., \$4.00	84. Evaluation Criteria and Priority Setting for State Highway Programs (1981) 32 pp., \$6.40
39. Transportation Requirements for the Handicapped, Elderly, and Economically Disadvantaged (1976) 54 pp. (out of print)	85. Energy Involved in Construction Materials and Procedures (1981) 34 pp., \$6.40
40. Staffing and Management for Social, Economic, and Environmental Impact Assessments (1977) 43 pp., \$4.00	86. Effects of Traffic-Induced Vibrations on Bridge Deck Repairs (1981) 40 pp., \$6.80
41. Bridge Bearings (1977) 62 pp. (microfiche)*	87. Highway Noise Barriers (1981) 81 pp., \$7.20
42. Design of Pile Foundations (1977) 68 pp., \$4.80	88. Underwater Inspection and Repair of Bridge Substructures (1981) 77 pp., \$7.60
43. Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation (1977) 57 pp., \$4.80 (supplemented by Synthesis 121)	89. Geotechnical Instrumentation for Monitoring Field Performance (1982) 46 pp., \$6.80
44. Consolidation of Concrete for Pavements, Bridge Decks, and Overlays (1977) 61 pp., \$4.80	90. New-Product Evaluation Procedures (1982) 34 pp., \$6.80
45. Rapid-Setting Materials for Patching of Concrete (1977) 13 pp. (out of print)	91. Highway Accident Analysis Systems (1982) 69 pp., \$7.60
46. Recording and Reporting Methods for Highway Maintenance Expenditures (1977) 35 pp., \$3.60	92. Minimizing Reflection Cracking of Pavement Overlays (1982) 38 pp., \$6.80

*These syntheses are available from TRB in microfiche form only at a cost of \$10.00 each.

Table 4 (continued)

No.	Title, Pages, Price	No.	Title, Pages, Price
93.	Coordination of Transportation System Management and Land Use Management (1982) 38 pp., \$6.80	142.	Methods of Cost-Effectiveness Analysis for Highway Projects (1988) 22 pp., \$7.00
94.	Photologging (1982) 38 pp., \$6.80	143.	Uniformity Efforts in Oversize/Overweight Permits (1988) 79 pp., \$10.00
95.	Statewide Transportation Planning (1982) 54 pp., \$7.20 (supersedes Synthesis 15)	144.	Breaking/Cracking and Sealing Concrete Pavements (1989) 39 pp., \$8.00
96.	Pavement Subsurface Drainage Systems (1982) 38 pp., \$6.80	145.	Staffing Considerations in Construction Engineering Management (1989) 42 pp., \$8.00
97.	Transit Ownership/Operation Options for Small Urban and Rural Areas (1982) 28 pp., \$6.40	146.	Use of Consultants for Construction Engineering and Inspection (1989) 64 pp., \$9.00
98.	Resealing Joints and Cracks in Rigid and Flexible Pavements (1982) 62 pp., \$7.20	147.	Treatment of Problem Foundations for Highway Embankments (1989) 72 pp., \$9.00
99.	Resurfacing with Portland Cement Concrete (1982) 90 pp., \$8.40	148.	Indicators of Quality in Maintenance (1989) 114 pp., \$11.00
100.	Managing State Highway Finance (1982) 23 pp., \$6.40	149.	Partnerships for Innovation: Private Sector Contributions to Innovation in the Highway Industry (1989) 45 pp., \$8.00
101.	Historic Bridges—Criteria for Decision Making (1983) 77 pp., \$8.00	150.	Technology Transfer in Selected Highway Agencies (1989) 38 pp., \$8.00
102.	Material Certification and Material-Certification Effectiveness (1983) 17 pp., \$6.00	151.	Process for Recapitalizing Highway Transportation Systems (1989) 43 pp., \$8.00
103.	Risk Assessment Processes for Hazardous Materials Transportation (1983) 26 pp., \$6.40	152.	Compaction of Asphalt Pavement (1989) 42 pp., \$8.00
104.	Criteria for Use of Asphalt Friction Surfaces (1983) 41 pp., \$6.80	153.	Evolution and Benefits of Preventive Maintenance Strategies (1989) 69 pp., \$9.00
105.	Construction Contract Claims: Causes and Methods of Settlement (1983) 58 pp., \$7.20	154.	Recycling Portland Cement Concrete Pavements (1989) 46 pp., \$8.00
106.	Practical Guidelines for Minimizing Tort Liability (1983) 40 pp., \$6.80	155.	Freeway Guide Sign Replacement: Policies and Criteria (1991) 37 pp., \$8.00
107.	Shallow Foundations for Highway Structures (1983) 38 pp., \$6.80	156.	Freeway Incident Management (1990) 23 pp., \$7.00
108.	Bridge Weight-Limit Posting Practices (1984) 30 pp., \$6.40	157.	Maintenance Management of Street and Highway Signs (1990) 134 pp., \$12.00
109.	Highway Uses of Epoxy with Concrete (1984) 68 pp., \$8.80	158.	Wet-Pavement Safety Programs (1990) 54 pp., \$8.00
110.	Maintenance Management Systems (1984) 49 pp., \$8.00	159.	Design and Construction of Bridge Approaches (1990) 45 pp., \$8.00
111.	Distribution of Wheel Loads on Highway Bridges (1984) 22 pp., \$7.20	160.	Cold-Recycled Bituminous Concrete Using Bituminous Materials (1990) 105 pp., \$11.00
112.	Cost-Effectiveness of Hot-Dip Galvanizing for Exposed Steel (1984) 28 pp., \$7.20	161.	Computer-Aided Design and Drafting Systems (1990) 24 pp., \$7.00
113.	Administration of Research, Development, and Implementation Activities in Highway Agencies (1984) 49 pp., \$8.00	162.	Signing Policies, Procedures, Practices, and Fees for Logo and Tourist-Oriented Directional Signing (1990) 41 pp., \$8.00
114.	Management of Traffic Signal Maintenance (1984) 134 pp., \$10.80 (supersedes Synthesis 22)	163.	Innovative Strategies for Upgrading Personnel in State Transportation Departments (1990) 35 pp., \$7.00
115.	Reducing Construction Conflicts between Highways and Utilities (1984) 73 pp., \$8.80	164.	Measures to Curtail State Fuel Tax Evasion (1990) 14 pp., \$7.00
116.	Asphalt Overlay Design Procedures (1984) 66 pp., \$8.40	165.	Transportation Telecommunications (1990) 92 pp., \$10.00 (supersedes Synthesis 12)
117.	Toll Highway Financing (1984) 29 pp., \$7.20	166.	Traffic Signal Control Equipment: State of the Art (1990) 43 pp., \$8.00
118.	Detecting Defects and Deterioration in Highway Structures (1985) 52 pp., \$8.00	167.	Measurements, Specifications, and Achievement of Smoothness for Pavement Construction (1990) 34 pp., \$8.00
119.	Prefabricated Bridge Elements and Systems (1985) 75 pp., \$8.80	168.	Contract Management Systems (1990) 74 pp., \$10.00
120.	Professional Resource Management and Forecasting (1985) 15 pp., \$6.80	169.	Removing Concrete from Bridges (1991) 42 pp., \$8.00
121.	Energy Conservation in Transportation (1985) 25 pp., \$7.20 (supplements Synthesis 43)	170.	Managing Urban Freeway Maintenance (1990) 32 pp., \$7.00
122.	Life-Cycle Cost Analysis of Pavements (1985) 136 pp., \$10.80	171.	Fabrics in Asphalt Overlays and Pavement Maintenance (1991) 72 pp., \$9.00
123.	Bridge Designs to Reduce and Facilitate Maintenance and Repair (1985) 65 pp., \$8.40	172.	Signal Timing Improvement Practices (1992) 88 pp., \$11.00
124.	Use of Weigh-in-Motion Systems for Data Collection and Enforcement (1986) 34 pp., \$7.60	173.	Short-Term Responsive Maintenance Systems (1991) 43 pp., \$9.00
125.	Maintenance Activities Accomplished by Contract (1986) 42 pp., \$8.00	174.	Stormwater Management for Transportation Facilities (1993) 81 pp., \$9.00
126.	Equipment for Obtaining Pavement Condition and Traffic Loading Data (1986) 118 pp., \$11.20	175.	Moisture Damage in Asphalt Concrete (1991) 91 pp., \$10.00
127.	Use of Fly Ash in Concrete (1986) 66 pp., \$8.40	176.	Bridge Paint: Removal, Containment, and Disposal (1992) 60 pp., \$9.00
128.	Methods for Identifying Hazardous Highway Elements (1986) 80 pp. (microfiche)*	177.	Freeway Corridor Management (1992) 64 pp., \$9.00
129.	Freezing and Thawing Resistance of High-Strength Concrete (1986) 31 pp., \$7.60	178.	Truck Escape Ramps (1992) 56 pp., \$9.00
130.	Traffic Data Collection and Analysis: Methods and Procedures (1986) 58 pp., \$8.40	179.	Latex-Modified Concretes and Mortars (1992) 58 pp., \$9.00
131.	Effects of Permit and Illegal Overloads on Pavements (1987) 99 pp., \$10.40	180.	Performance Characteristics of Open-Graded Friction Courses (1992) 44 pp., \$8.00 (supplements Synthesis 49)
132.	System-Wide Safety Improvements: An Approach to Safety Consistency (1987) 20 pp., \$6.80	181.	In-Service Experience with Traffic Noise Barriers (1992) 61 pp., \$9.00
133.	Integrated Highway Information Systems (1987) 31 pp., \$7.60	182.	Performance and Operational Experience of Truck-Mounted Attenuators (1992) 54 pp., \$9.00
134.	D-Cracking of Concrete Pavements (1987) 34 pp., \$7.60	183.	Knowledge Based Expert Systems in Transportation (1992) 52 pp., \$9.00
135.	Pavement Management Practices (1987) 139 pp., \$12.40	184.	Disposal of Roadside Litter Mixtures (1993) 52 pp., \$12.00
136.	Protective Coatings for Bridge Steel (1987) 107 pp., \$11.00	185.	Preferential Lane Treatments for High-Occupancy Vehicles (1993) 80 pp., \$10.00
137.	Negotiating and Contracting for Professional Engineering Services (1988) 75 pp., \$9.60	186.	Supplemental Advance Warnings (1993) 83 pp., \$19.00
138.	Pavement Markings: Materials and Application for Extended Service Life (1988) 45 pp., \$8.00 (supersedes Synthesis 17)	187.	Rapid Test Methods for Asphalt Concrete and Portland Cement Concrete (1993) 47 pp., \$10.00
139.	Pedestrians and Traffic Control Measures (1988) 75 pp., \$9.00	188.	Management Training and Development Programs (1993) 56 pp., \$15.00
140.	Durability of Prestressed Concrete Highway Structures (1988) 65 pp., \$9.00	189.	State Highway Pavement Design Practices (1993) 45 pp., \$11.00
141.	Bridge Deck Joints (1989) 66 pp., \$9.00	190.	Criteria for Qualifying Contractors for Bidding Purposes (1994) 40 pp., \$11.00
		191.	Use of Rumble Strips to Enhance Safety (1993) 74 pp., \$19.00
		192.	Accident Data Quality (1993) 53 pp., \$12.00
		193.	Hot In-Place Recycling of Asphalt Concrete (1994) 69 pp., \$16.00

*These syntheses are available from TRB in microfiche form only at a cost of \$10.00 each.

Table 4 (continued)

No. Title, Pages, Price	No. Title, Pages, Price
194. Electronic Toll and Traffic Management (ETTM) Systems (1993) 64 pp., \$15.00	213. Effective Use of Park-and-Ride Facilities (1995) 45 pp., \$11.00
195. Use of Warranties in Road Construction (1994) 60 pp., \$15.00	214. Resolution of Disputes to Avoid Construction Claims (1995) 39 pp., \$13.00
196. Highway Maintenance Procedures Dealing with Hazardous Materials Incidents (1994) 60 pp., \$15.00	215. Determination of Contract Time for Highway Construction Projects (1995) 43 pp., \$11.00
197. Corridor Preservation (1994) 43 pp., \$11.00	216. Implementation of Technology From Abroad (1995) 44 pp., \$11.00
198. Uses of Recycled Rubber Tires in Highways (1994) 162 pp., \$23.00	217. Consideration of the 15 Factors in the Metropolitan Planning Process (1995) 55 pp., \$14.00
199. Recycling and Use of Waste Materials and By-Products in Highway Construction (1994) 84 pp., \$20.00	218. Pavement Markings (In press)
200. Underwater Bridge Maintenance and Repair (1994) 54 pp., \$16.00	219. Photographic Enforcement of Traffic Laws (1995) 67 pp., \$18.00
201. Multimodal Evaluation in Passenger Transportation (1994) 84 pp., \$19.00	220. Waterproofing Membranes for Concrete Bridge Decks (1995) 76 pp., \$21.00
202. Severity Indices for Roadside Features (1994) 54 pp., \$12.00	221. Effects of Highway Widening Improvements on Urban and Suburban Areas (1996) 43 pp., \$13.00
203. Current Practices in Determining Pavement Condition (1994) 57 pp., \$16.00	222. Pavement Management Methodologies to Select Projects and Recommend Preservation Treatments (1995) 96 pp., \$22.00
204. Portland Cement Concrete Resurfacing (1994) 67 pp., \$15.00	223. Cost-Effective Preventive Maintenance of Pavements (1996) 103 pp., \$22.00
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