

# NCHRP

National Cooperative Highway Research Program

# RESEARCH RESULTS DIGEST

December 1993

Number 195

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: Frank R. McCullagh

## 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, Manger, Synthesis Studies, Stephen F. Maher, and Donna L. Vlasak, 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 specific 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 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.

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, or Donna L. Vlasak at 202-334-3242

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; (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 1994*

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, or Donna L. Vlasak, who can be reached at (202) 334-3242.

#### *Submission and Selection of Topics*

One part of the project procedures that is not widely understood is the process for submission and selection of topics. NCHRP Project Committee SP20-5 meets each Fall 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 to 14 syntheses per year. This number and some alternative topics are selected by the committee at the Fall meeting. It is unlikely that those near the bottom of the list in Table 2 will be studied at this time.

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, and AASHTO and TRB committees.

#### *Available Publications*

The Syntheses of Highway Practice that have been completed under this project are listed in Table 4. Two 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.

#### *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. Comments from these reviews are incorporated into the final report, which is usually published as an NCHRP Synthesis of Highway Practice.

#### *Index of Topic Subjects*

Table 5 is an index to published syntheses and topics under study, as well as those expected to be started through 1994.

Table 1  
TOPICS BEING STUDIED

No.	Title	No.	Title
17-05	Design, Construction, and Maintenance of PCC Pavement Joints	24-05	Pavement Management Methodologies to Select Projects and Recommend Preservation Treatments
19-22	Status and Application of GPS Satellite Positioning for Departments of Transportation	24-07	Pavement Markings
20-22	Highway Tort Liability Management Programs	24-08	Longitudinal Occupancy of Limited/Controlled Access Right-of-Way by Utilities
21-08	Development and Implementation of Traffic Control Plans for Highway Work Zones	24-10	Asphalt Surface Treatments and Thin Overlays
22-02	Uses of Recycled Rubber Tires in Highways	24-11	Implementation of Technologies from Abroad
22-04	Underwater Bridge Maintenance and Repair	24-12	Sealers for Portland Cement Concrete Highway Facilities
22-07	Current Practices in Determining Pavement Condition	24-13	Effects of Highway Widening Improvements on Urban and Suburban Areas
22-10	Recycling and Use of Waste Materials and By-Products in Highway Construction	25-01	Applications of 3D and 4D Visual Modeling for Transportation Systems
22-11	Photographic Enforcement of Traffic Laws	25-02	Methodologies Associated with Freight Planning
22-12	Truck Operating Characteristics	25-03	Left Turn Treatments at Intersections
22-14	Impacts of Highway Bypasses on Rural Communities and Small Urban Areas	25-04	Highway Guiderail and Median Barrier Crashworthiness
23-03	Managing Roadway Snow and Ice Control Operations	25-06	Collecting and Managing Cost Data for Bridge Management Systems
23-04	Multimodal Evaluation in Passenger Transportation	25-07	Pavement Subsurface Drainage Systems
23-05	Relationship of Current Construction Specifications to Performance	25-09	Waterproofing Membranes for Bridge Decks
23-09	Severity Indices for Roadside Features	25-10	Cost-Effective Preventive Pavement Maintenance
23-10	Portland Cement Concrete Resurfacing	25-11	Toll Plaza Design
23-11	Changeable Message Signs	25-12	Transportation Systems Management
23-12	Reduced Visibility on the Highway	25-13	Procedures MPOs Use to Consider the 15 Factors in Developing Plans and Programs Under the ISTEA
23-13	Effective Use of Park-and-Ride Facilities	25-14	Managing Contract Research Programs
24-01	Resolution of Disputes to Avoid Construction Claims	25-15	Productivity Measurements within DOTs
24-02	International Survey of Roadway Pricing	25-16	Dynamic Effects of Pile Installations on Adjacent Structures
24-03	Performance and Operational Experience of Crash Cushions	25-21	Service Life of Drainage Pipe
24-04	Determination of Contract Time for Highway Construction Projects		

Table 2  
SYNTHESIS TOPICS SELECTED FOR THE FY 1994 PROGRAM

No.	Title	No.	Title
26-01	On-Site Remediation of Contaminated Soils	26-11	Transportation Development Process
26-02	Variability in Highway Construction	26-12	Alternate Methods of Bridge Steel Protection
26-03	Standards for Travel Surveys	26-13	Total Quality Management (TQM) in Transportation Agencies
26-04	Highway-Railroad Grade Crossings	26-14	Traffic Signal Maintenance Management
26-05	Long-Term Noise Characteristics of Pavement Surface Texture	26-15	Use of Wetland Mitigation for Water Quality Control
26-06	Land Development Regulations that Support Access Management	26-16	Videologging
26-07	Application of Full-Scale Accelerated Pavement Testing	26-17	Employee Travel Reduction Programs (ETRP) Strategies and Their Potential Impact
26-08	Ground Penetrating Radar (GPR) for Evaluating Subsurface Conditions for Transportation Facilities	26-18	Soil Stabilization for Pavements
26-09	Evaluation of Training	26-19	Design, Operation, and Maintenance of Roadways in Seasonal Frost Areas
26-10	Settlement of Bridge Approaches	26-20	Mobile Source Emissions Inventories: Methodology and Process

Table 3  
NCHRP PROJECT COMMITTEE SP20-5

Chairman  
Jon P. Underwood  
Texas Department of Transportation

Kenneth C. Afferton  
New Jersey Dept. of Transportation  
Robert N. Bothman  
The HELP Program  
John J. Henry  
Pennsylvania Transportation Institute  
Gloria J. Jeff  
Michigan Dept. of Transportation  
Earl C. Shirley  
California Dept. of Transportation

Thomas O. Willett  
Federal Highway Administration  
J. Richard Young, Jr.  
Mississippi Dept. of Transportation  
Richard A. McComb (Liaison)  
Federal Highway Administration  
Robert E. Spicher (Liaison)  
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	53.	Precast Concrete Elements for Transportation Facilities (1978) 48 pp., \$5.60
2.	Bridge Approach Design and Construction Practices (1969) 30 pp. (microfiche)*	54.	Recycling Materials for Highways (1978) 53 pp. (microfiche)*
3.	Traffic-Safe and Hydraulically Efficient Drainage Practice (1969) 38 pp. (microfiche)*	55.	Storage and Retrieval Systems for Highway and Transportation Data (1978) 30 pp., \$4.80
4.	Concrete Bridge Deck Durability (1970) 28 pp. (microfiche)* (supplemented by Synthesis 57)	56.	Joint-Related Distress in PCC Pavement—Cause, Prevention and Rehabilitation (1979) 36 pp., \$5.20
5.	Scour at Bridge Waterways (1970) 37 pp. (microfiche)*	57.	Durability of Concrete Bridge Decks (1979) 61 pp. (microfiche)* (supplements Synthesis 4)
6.	Principles of Project Scheduling and Monitoring (1970) 43 pp. (microfiche)*	58.	Consequences of Deferred Maintenance (1979) 24 pp., \$4.40
7.	Motorist Aid Systems (1971) 28 pp., \$2.40	59.	Relationship of Asphalt Cement Properties to Pavement Durability (1979) 43 pp., \$5.60
8.	Construction of Embankments (1971) 38 pp. (microfiche)*	60.	Failure and Repair of Continuously Reinforced Concrete Pavement (1979) 42 pp., \$5.60
9.	Pavement Rehabilitation - Materials and Techniques (1972) 41 pp. (out of print)	61.	Changeable Message Signs (1979) 37 pp., \$5.60
10.	Recruiting, Training, and Retaining Maintenance and Equipment Personnel (1972) 35 pp. (microfiche)*	62.	Potential State Resources for Financing Transportation Programs (1979) 34 pp., \$5.20
11.	Development of Management Capability (1972) 50 pp. (out of print)	63.	Design and Use of Highway Shoulders (1979) 26 pp., \$4.80
12.	Telecommunications Systems for Highway Administration and Operations (1972) 39 pp., \$2.80 (superseded by Synthesis 165)	64.	Bituminous Patching Mixtures (1979) 26 pp., \$4.80
13.	Radio Spectrum Frequency Management (1972) 32 pp., \$2.80	65.	Quality Assurance (1979) 42 pp., \$5.60
14.	Skid Resistance (1972) 66 pp. (microfiche)*	66.	Glare Screen Guidelines (1979) 17 pp., \$4.40
15.	Statewide Transportation Planning - Needs and Requirements (1973) 41 pp. (microfiche)* (superseded by Synthesis 95)	67.	Bridge Drainage Systems (1979) 44 pp., \$5.60
16.	Continuously Reinforced Concrete Pavement (1973) 23 pp., \$2.80	68.	Motor Vehicle Size and Weight Regulation, Enforcement, and Permit Operations (1980) 45 pp., \$6.00
17.	Pavement Traffic Marking - Materials and Application Affecting Serviceability (1973) 44 pp., \$3.60 (superseded by Synthesis 138)	69.	Bus Route and Schedule Planning Guidelines (1980) 99 pp., \$8.00
18.	Erosion Control on Highway Construction (1973) 52 pp. (microfiche)*	70.	Design of Sedimentation Basins (1980) 53 pp., \$6.80
19.	Design, Construction, and Maintenance of PCC Pavement Joints (1973) 40 pp. (out of print)	71.	Direction Finding from Arterials to Destinations (1980) 50 pp., \$6.40
20.	Rest Areas (1973) 38 pp., \$3.60	72.	Transportation Needs Studies and Financial Constraints (1980) 54 pp., \$6.40
21.	Highway Location Reference Methods (1974) 30 pp., \$3.20	73.	Alternative Work Schedules: Impacts on Transportation (1980) 54 pp., \$6.80
22.	Maintenance Management of Traffic Signal Equipment and Systems (1974) 41 pp. (microfiche)* (superseded by Synthesis 114)	74.	State Transit-Management Assistance to Local Communities (1980) 34 pp., \$6.00
23.	Getting Research Findings Into Practice (1974) 24 pp., \$3.20	75.	Transit Boards-Composition, Roles, and Procedures (1981) 24 pp., \$6.20
24.	Minimizing Deicing Chemical Use (1974) 58 pp. (microfiche)*	76.	Collection and Use of Pavement Condition Data (1981) 74 pp., \$8.00
25.	Reconditioning High-Volume Freeways in Urban Areas (1974) 56 pp., \$4.00	77.	Evaluation of Pavement Maintenance Strategies (1981) 56 pp., \$7.40
26.	Roadway Design in Seasonal Frost Areas (1975) 104 pp. (microfiche)*	78.	Value Engineering in Preconstruction and Construction (1981) 23 pp., \$6.40
27.	PCC Pavements for Low-Volume Roads and City Streets (1975) 31 pp. (microfiche)*	79.	Contract Time Determination (1981) 45 pp., \$7.20
28.	Partial-Lane Pavement Widening (1975) 30 pp., \$3.20	80.	Formulating and Justifying Highway Maintenance Budgets (1981) 49 pp., \$7.20
29.	Treatment of Soft Foundations for Embankments (1975) 25 pp., \$3.20 (supplemented by Synthesis 147)	81.	Experiences in Transportation System Management (1981) 88 pp., \$8.40
30.	Bituminous Emulsions for Highway Pavements (1975) 76 pp. (microfiche)*	82.	Criteria for Evaluation of Truck Weight Enforcement Programs (1981) 74 pp., \$7.20
31.	Highway Tunnel Operations (1975) 29 pp., \$3.20	83.	Bus Transit Accessibility for the Handicapped in Urban Areas (1981) 73 pp., \$7.60
32.	Effects of Studded Tires (1975) 46 pp., \$4.00	84.	Evaluation Criteria and Priority Setting for State Highway Programs (1981) 32 pp., \$6.40
33.	Acquisition and Use of Geotechnical Information (1976) 40 pp., \$4.00	85.	Energy Involved in Construction Materials and Procedures (1981) 34 pp., \$6.40
34.	Policies for Accommodation of Utilities on Highway Rights of Way (1976) 22 pp. (microfiche)*	86.	Effects of Traffic-Induced Vibrations on Bridge Deck Repairs (1981) 40 pp., \$6.80
35.	Design and Control of Freeway Off-Ramp Terminals (1976) 61 pp., \$4.40	87.	Highway Noise Barriers (1981) 81 pp., \$7.20
36.	Instrumentation and Equipment for Testing Highway Materials, Products, and Performance (1976) 70 pp., \$4.80	88.	Underwater Inspection and Repair of Bridge Substructures (1981) 77 pp., \$7.60
37.	Lime-Fly Ash-Stabilized Bases and Subbases (1976) 66 pp. (microfiche)*	89.	Geotechnical Instrumentation for Monitoring Field Performance (1982) 46 pp., \$6.80
38.	Statistically Oriented End-Result Specifications (1976) 40 pp., \$4.00	90.	New-Product Evaluation Procedures (1982) 34 pp., \$6.80
39.	Transportation Requirements for the Handicapped, Elderly, and Economically Disadvantaged (1976) 54 pp. (out of print)	91.	Highway Accident Analysis Systems (1982) 69 pp., \$7.60
40.	Staffing and Management for Social, Economic, and Environmental Impact Assessments (1977) 43 pp., \$4.00	92.	Minimizing Reflection Cracking of Pavement Overlays (1982) 38 pp., \$6.80
41.	Bridge Bearings (1977) 62 pp. (microfiche)*	93.	Coordination of Transportation System Management and Land Use Management (1982) 38 pp., \$6.80
42.	Design of Pile Foundations (1977) 68 pp., \$4.80	94.	Photologging (1982) 38 pp., \$6.80
43.	Energy Effects, Efficiencies, and Prospects for Various Modes of Transportation (1977) 57 pp., \$4.80 (supplemented by Synthesis 121)	95.	Statewide Transportation Planning (1982) 54 pp., \$7.20 (supersedes Synthesis 15)
44.	Consolidation of Concrete for Pavements, Bridge Decks, and Overlays (1977) 61 pp., \$4.80	96.	Pavement Subsurface Drainage Systems (1982) 38 pp., \$6.80
45.	Rapid-Setting Materials for Patching of Concrete (1977) 13 pp. (out of print)	97.	Transit Ownership/Operation Options for Small Urban and Rural Areas (1982) 28 pp., \$6.40
46.	Recording and Reporting Methods for Highway Maintenance Expenditures (1977) 35 pp., \$3.60	98.	Resealing Joints and Cracks in Rigid and Flexible Pavements (1982) 62 pp., \$7.20
47.	Effect of Weather on Highway Construction (1978) 29 pp., \$3.20	99.	Resurfacing with Portland Cement Concrete (1982) 90 pp., \$8.40
48.	Priority Programming and Project Selection (1978) 31 pp. (out of print)	100.	Managing State Highway Finance (1982) 23 pp., \$6.40
49.	Open-Graded Friction Courses for Highways (1978) 50 pp., \$4.00	101.	Historic Bridges-Criteria for Decision Making (1983) 77 pp., \$8.00
50.	Durability of Drainage Pipe (1978) 37 pp. (microfiche)*	102.	Material Certification and Material-Certification Effectiveness (1983) 17 pp., \$6.00
51.	Construction Contract Staffing (1978) 62 pp., \$6.00		
52.	Management and Selection Systems for Highway Maintenance Equipment (1978) 17 pp., \$4.40		

\*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
103.	Risk Assessment Processes for Hazardous Materials Transportation (1983) 26 pp., \$6.40	149.	Partnerships for Innovation: Private Sector Contributions to Innovation in the Highway Industry (1989) 45 pp., \$8.00
104.	Criteria for Use of Asphalt Friction Surfaces (1983) 41 pp., \$6.80	150.	Technology Transfer in Selected Highway Agencies (1989) 38 pp., \$8.00
105.	Construction Contract Claims: Causes and Methods of Settlement (1983) 58 pp., \$7.20	151.	Process for Recapitalizing Highway Transportation Systems (1989) 43 pp., \$8.00
106.	Practical Guidelines for Minimizing Tort Liability (1983) 40 pp., \$6.80	152.	Compaction of Asphalt Pavement (1989) 42 pp., \$8.00
107.	Shallow Foundations for Highway Structures (1983) 38 pp., \$6.80	153.	Evolution and Benefits of Preventive Maintenance Strategies (1989) 69 pp., \$9.00
108.	Bridge Weight-Limit Posting Practices (1984) 30 pp., \$6.40	154.	Recycling Portland Cement Concrete Pavements (1989) 46 pp., \$8.00
109.	Highway Uses of Epoxy with Concrete (1984) 68 pp., \$8.00	155.	Freeway Guide Sign Replacement: Policies and Criteria (1991) 37 pp., \$8.00
110.	Maintenance Management Systems (1984) 49 pp., \$8.00	156.	Freeway Incident Management (1990) 23 pp., \$7.00
111.	Distribution of Wheel Loads on Highway Bridges (1984) 22 pp., \$7.20	157.	Maintenance Management of Street and Highway Signs (1990) 134 pp., \$12.00
112.	Cost-Effectiveness of Hot-Dip Galvanizing for Exposed Steel (1984) 28 pp., \$7.20	158.	Wet-Pavement Safety Programs (1990) 54 pp., \$8.00
113.	Administration of Research, Development, and Implementation Activities in Highway Agencies (1984) 49 pp., \$8.00	159.	Design and Construction of Bridge Approaches (1990) 45 pp., \$8.00
114.	Management of Traffic Signal Maintenance (1984) 134 pp., \$10.80 (supersedes Synthesis 22)	160.	Cold-Recycled Bituminous Concrete Using Bituminous Materials (1990) 105 pp., \$11.00
115.	Reducing Construction Conflicts between Highways and Utilities (1984) 73 pp., \$8.80	161.	Computer-Aided Design and Drafting Systems (1990) 24 pp., \$7.00
116.	Asphalt Overlay Design Procedures (1984) 66 pp., \$8.40	162.	Signing Policies, Procedures, Practices, and Fees for Logo and Tourist-Oriented Directional Signing (1990) 41 pp., \$8.00
117.	Toll Highway Financing (1984) 29 pp., \$7.20	163.	Innovative Strategies for Upgrading Personnel in State Transportation Departments (1990) 35 pp., \$7.00
118.	Detecting Defects and Deterioration in Highway Structures (1985) 52 pp., \$8.00	164.	Measures to Curtail State Fuel Tax Evasion (1990) 14 pp., \$7.00
119.	Prefabricated Bridge Elements and Systems (1985) 75 pp., \$8.80	165.	Transportation Telecommunications (1990) 92 pp., \$10.00 (supersedes Synthesis 12)
120.	Professional Resource Management and Forecasting (1985) 15 pp., \$6.80	166.	Traffic Signal Control Equipment: State of the Art (1990) 43 pp., \$8.00
121.	Energy Conservation in Transportation (1985) 25 pp., \$7.20 (supplements Synthesis 43)	167.	Measurements, Specifications, and Achievement of Smoothness for Pavement Construction (1990) 34 pp., \$8.00
122.	Life-Cycle Cost Analysis of Pavements (1985) 136 pp., \$10.80	168.	Contract Management Systems (1990) 74 pp., \$10.00
123.	Bridge Designs to Reduce and Facilitate Maintenance and Repair (1985) 65 pp., \$8.40	169.	Removing Concrete from Bridges (1991) 42 pp., \$8.00
124.	Use of Weigh-in-Motion Systems for Data Collection and Enforcement (1986) 34 pp., \$7.60	170.	Managing Urban Freeway Maintenance (1990) 32 pp., \$7.00
125.	Maintenance Activities Accomplished by Contract (1986) 42 pp., \$8.00	171.	Fabrics in Asphalt Overlays and Pavement Maintenance (1991) 72 pp., \$9.00
126.	Equipment for Obtaining Pavement Condition and Traffic Loading Data (1986) 118 pp., \$11.20	172.	Signal Timing Improvement Practices (1992) (in press)
127.	Use of Fly Ash in Concrete (1986) 66 pp., \$8.40	173.	Short-Term Responsive Maintenance Systems (1991) 43 pp., \$9.00
128.	Methods for Identifying Hazardous Highway Elements (1986) 80 pp. (microfiche)*	174.	Stormwater Management for Transportation Facilities (1993) 81 pp., \$9.00
129.	Freezing and Thawing Resistance of High-Strength Concrete (1986) 31 pp., \$7.60	175.	Moisture Damage in Asphalt Concrete (1991) 91 pp., \$10.00
130.	Traffic Data Collection and Analysis: Methods and Procedures (1986) 58 pp., \$8.40	176.	Bridge Paint: Removal, Containment, and Disposal (1992) 60 pp., \$9.00
131.	Effects of Permit and Illegal Overloads on Pavements (1987) 99 pp., \$10.40	177.	Freeway Corridor Management (1992) 64 pp., \$9.00
132.	System-Wide Safety Improvements: An Approach to Safety Consistency (1987) 20 pp., \$6.80	178.	Truck Escape Ramps: (1992) 56 pp., \$9.00
133.	Integrated Highway Information Systems (1987) 31 pp., \$7.60	179.	Latex-Modified Concretes and Mortars (1992)
134.	D-Cracking of Concrete Pavements (1987) 34 pp., \$7.60	180.	Performance Characteristics of Open-Graded Friction Courses (1992) 44 pp., \$8.00 (supplements Synthesis 49)
135.	Pavement Management Practices (1987) 139 pp., \$12.40	181.	In-Service Experience with Traffic Noise Barriers (1992) 61 pp., \$9.00
136.	Protective Coatings for Bridge Steel (1987) 107 pp., \$11.00	182.	Performance and Operational Experience of Truck-Mounted Attenuators (1992) 54 pp., \$9.00
137.	Negotiating and Contracting for Professional Engineering Services (1988) 75 pp., \$9.60	183.	Knowledge Based Wxpert Systems in Transportation (1992) 52 pp., \$9.00
138.	Pavement Markings: Materials and Application for Extended Service Life (1988) 45 pp., \$8.00 (supersedes Synthesis 17)	184.	Disposal of Roadside Litter Mixtures (1993) 52 pp., \$12.00
139.	Pedestrians and Traffic Control Measures (1988) 75 pp., \$9.00	185.	Preferential Lane Treatments for High-Occupancy Vehicles (1993) 80 pp., \$10.00
140.	Durability of Prestressed Concrete Highway Structures (1988) 65 pp., \$9.00	186.	Supplemental Advance Warnings (1993) 83pp., \$19.00
141.	Bridge Deck Joints (1989) 66 pp., \$9.00	187.	Rapid Test Methods for Asphalt Concrete and Portland Cement Concrete (1993) 47 pp., \$10.00
142.	Methods of Cost-Effectiveness Analysis for Highway Projects (1988) 22 pp., \$7.00	188.	Management Training and Development Programs (1994) (in press)
143.	Uniformity Efforts in Oversize/Overweight Permits (1988) 79 pp., \$10.00	189.	State Highway Pavement Design Practices (1993) 45pp., \$11.00
144.	Breaking/Cracking and Seating Concrete Pavements (1989) 39 pp., \$8.00	190.	Criteria for Qualifying Contractors for Bidding Purposes (1994) (in press)
145.	Staffing Considerations in Construction Engineering Management (1989) 42 pp., \$8.00	191.	Use of Rumble Strips to Enhance Safety (1993) 74 pp., \$19.00
146.	Use of Consultants for Construction Engineering and Inspection (1989) 64 pp., \$9.00	192.	Accident Data Quality (1993) 53 pp., \$12.00
147.	Treatment of Problem Foundations for Highway Embankments (1989) 72 pp., \$9.00	193.	Hot In-Place Recycling of Asphalt Concrete (1994) (in press)
148.	Indicators of Quality in Maintenance (1989) 114 pp., \$11.00	194.	Electronic Toll and Traffic Management (ETTM) Systems (1993) 64 pp., \$15.00
		195.	Use of Warranties in Road Construction (1994) (in press)
		196.	Highway Maintenance Procedures Dealing with Hazardous Materials Incidents (1994) (in press)
		197.	Corridor Preservation (1994) (in press)
<b>Research Results Digests (RRD)</b>			
100.	Safe Conduct of Traffic Through Highway Construction and Maintenance Zones (1978) 5 pp., \$1.00	106.	Use of Waste Materials in Highway Construction and Maintenance (1979) 2 pp., \$1.00

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

Table 5  
INDEX TO SYNTHESSES AND STUDIES\*

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