NCHRP
National Cooperative Highway Research Program

# RESEARCH RESULTS DIGEST

December 1990 Number 175



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.

**Area of Interest: 33 Construction (01 Highway Transportation)**

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## NCHRP Research on Construction Engineering

*An NCHRP digest of the progress and status of construction engineering research under the National Cooperative Highway Research Program prepared by Lloyd R. Crowther, Consultant.*

Since its inception in 1962, the National Cooperative Highway Research Program (NCHRP) has included numerous studies of interest to construction engineers. As an easy reference, this Digest outlines the status of all NCHRP research related to highway construction (see Tables 1 through 5). These research projects are primarily applied research -- research aimed at producing results applicable by the practitioner.

Although the NCHRP is administered by the Transportation Research Board (TRB), it is sponsored by the member departments, i.e., the individual state departments of transportation (DOTs), of the American Association of State Highway and Transportation Officials (AASHTO) in cooperation with the Federal Highway Administration (FHWA), U.S. Department of Transportation. The state DOTs are the sole financial sponsors of the NCHRP. Such support is voluntary and uses funds from the states' Federal-aid apportionment of Highway Planning and Research (HPR) funds. The NCHRP is carried out under a three-way agreement between AASHTO, FHWA, and the National Academy of Sciences, TRB's parent organization.

Subject to an eventual two-thirds endorsement by the state DOTs, the AASHTO Standing Committee on Research (SCOR) is responsible for formulating the annual program for the NCHRP. SCOR selects projects from the numerous recommendations that are submitted annually in response to a solicitation from four authorized sources:

- Chief administrative officers of the state DOTs
- Chairmen of subcommittees under AASHTO's Standing Committees on Highway and Administration
- the AASHTO Executive Committee
- the Federal Highway Administration.

These are the only sources from which problems can be submitted. Therefore, anyone interested in suggesting a research project that would result in a practical application to an immediate transportation problem shared nationwide, should seek consideration for a submittal through one of the sources listed above.

For each project assigned to the NCHRP, an expert panel, comprised of persons knowledgeable in the subject of interest, is formed to refine the scope of work, which is then used as part of a request for proposals. The expert panel evaluates the proposals received, selects a qualified research agency (from academia, private industry, or government), and then provides the needed technical oversight until the project is complete.

TABLE 3 AVAILABLE NCHRP SERIES PUBLICATIONS

| No. | Title | Research Agency | Pages | Cost ($) | Year |
|---|---|---|---|---|---|
| **(a) NCHRP Reports** | | | | | |
| 5 | Effects of Different Methods of Stockpiling Aggregates - Interim Report | Miller-Warden Associates | 48 | * | 1964 |
| 8 | Synthetic Aggregates for Highway Construction | Battelle Memorial Institute | 13 | * | 1964 |
| 12 | Identification of Aggregates Causing Poor Concrete Performance When Frozen - Interim Report | Virginia Polytechnic Institute | 47 | * | 1964 |
| 14 | Density and Moisture Content Measurements by Nuclear Methods - Interim Report | Research Triangle Institute | 32 | * | 1964 |
| 15 | Identification of Concrete Aggregates Establishing Frost Susceptibility - Interim Report | The Pennsylvania State University | 66 | * | 1965 |
| 16 | Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals | Battelle Memorial Institute | 21 | * | 1965 |
| 17 | Development of Guidelines for Practical and Realistic Construction Specifications | Miller-Warden Associates | 109 | * | 1964 |
| 23 | Methods for Reducing Corrosion of Reinforcing Steel | Battelle Memorial Institute | 22 | * | 1965 |
| 25 | Potential Uses of Sonic and Ultrasonic Devices in Highway Construction | The Ohio State University | 48 | * | 1965 |
| 26 | Development of Uniform Procedures for Establishing Construction Equipment Rental Rates | Ernst & Ernst | 33 | * | 1966 |
| 27 | Physical Factors Influencing Resistance of Concrete to Deicing Agents | University of Illinois | 41 | * | 1965 |
| 34 | Evaluation of Construction Control Procedures - Interim Report | Miller-Warden Associates | 117 | * | 1966 |
| 38 | Evaluation of Pavement Joint and Crack Sealing Materials and Practices | Rensselaer Polytechnic Institute | 40 | * | 1966 |
| 43 | Density and Moisture Content Measurements by Nuclear Methods | Research Triangle Institute | 38 | * | 1966 |
| 46 | Effects of different Methods of Stockpiling and Handling Aggregates | Miller-Warden Associates | 102 | * | 1965 |
| 52 | Measurement of Pavement Thickness by Rapid and Nondestructive Methods | ITT Research Institute | 82 | * | 1966 |
| 65 | One-Cycle Slow-Freeze Test for Evaluating Aggregate Performance in Frozen Concrete | Virginia Polytechnic Institute | 21 | * | 1967 |
| 66 | Identification of Frost-Susceptible Particles in Concrete Aggregates | The Pennsylvania State University | 62 | * | 1967 |
| 69 | Evaluation of Construction Control Procedures - Aggregate Gradation Variations and Effects | Materials Research and Development | 58 | * | 1967 |
| 74 | Protective Coatings for Highway Structural Steel | Steel Structures Painting Council | 64 | * | 1966 |
| 74B | Protective Coatings for Highway Structural Steel - Current Highway Practices | Steel Structures Painting Council | 102 | * | 1966 |
| 98 | Tests for Evaluating Degradation of Base Course Aggregates | Purdue University | 98 | * | 1966 |
| 103 | Rapid Test Methods for Field Control of Highway Construction | Clemson University | 89 | * | 1965 |
| 105 | Revibration of Retarded Concrete for Continuous Bridge Decks | University of Illinois | 67 | * | 1969 |
| 125 | Optimization of Density and Moisture Control Measurements by Nuclear Methods | North Carolina State University | 86 | * | 1970 |
| 135 | Promising Replacements for Conventional Aggregates for Highway Use | University of Illinois | 53 | * | 1971 |
| 166 | Waste Materials as Potential Replacements for Highway Aggregates | Valley Forge Laboratories | 94 | 5.60 | 1973 |
| 168 | Rapid Measurement of Concrete Thickness and Reinforcement Location - Field Evaluation of Nondestructive Systems | Pennsylvania Dept. of Transportation | 63 | 4.80 | 1973 |

* Out of print publications are available in microfiche from the Transportation Research Board. The cost is $8.00 per publication.

TABLE 3 - Continued

| No. | Title | Research Agency | Pages | Cost ($) | Year |
|---|---|---|---|---|---|
| **(a) NCHRP Reports** | | | | | |
| 172 | Density Standards for Field Compaction of Granular Bases and Subbases | Clemson University | 73 | * | 1973 |
| 190 | Use of Polymers in Highway Concrete | Lehigh University | 77 | 5.60 | 1975 |
| 191 | Effect of Air Pollution Regulations on Highway Construction and Maintenance | Howard, Needles, Tammen, & Bergendoff | 81 | * | 1975 |
| 195 | Minimizing Premature Cracking in Asphaltic Concrete Pavement | Materials Research & Development | 51 | 6.00 | 1973 |
| 196 | Reconditioning Heavy-Duty Freeways in Urban Areas | Texas A&M University | 60 | 6.40 | 1976 |
| 201 | Acceptance Criteria for Electroslag Weldments in Bridges | United States Steel Corporation | 44 | 5.20 | 1978 |
| 204 | Bridge Deck Joint-Sealing Systems - Evaluation and Performance Specification | Howard, Needles, Tammen, & Bergendoff | 46 | 5.60 | 1978 |
| 207 | Upgrading of Low-Quality Aggregates for PCC and Bituminous Pavements | The Pennsylvania State University | 91 | * | 1979 |
| 221 | Erosion Control During Highway Construction - Manual on Principles and Practices | Utah State University | 108 | 14.40 | 1979 |
| 224 | Guidelines for Recycling Pavement Materials | Texas A&M University | 137 | 9.20 | 1979 |
| 225 | Plastic Pipe for Subsurface Drainage of Transportation Facilities | Simpson Gumpertz & Heger | 153 | 9.60 | 1979 |
| 236 | Evaluation of Traffic Controls for Highway Work Zones | BioTechnology, Inc. | 189 | 12.00 | 1981 |
| 237 | Locating Voids Beneath Pavement Using Pulsed Electromagnetic Wave Techniques | Georgia Tech Research Corporation | 40 | * | 1981 |
| 242 | Ultrasonic Mearsument of Weld Flaw Size | The Welding Institute (England) | 76 | 8.00 | 1982 |
| 251 | Assessment of Deficiencies and Preservation of Bridge Substructures Below the Waterline | Byrd, Tallamy, MacDonald & Lewis | 80 | 8.40 | 1982 |
| 252 | Adding Dust Collector Fines to Asphalt Paving Mixtures | The Pennsylvania State University | 90 | 8.40 | 1982 |
| 258 | Control of Air Content in Concrete | Construction Tech. Laboratories/PCA | 84 | 8.40 | 1983 |
| 268 | Influence of Asphalt Temperature Susceptibility on Pavement Construction and Performance | Texas A&M University | 62 | 7.60 | 1984 |
| 269 | Paving with Asphalt Cements Produced in the 1980's | Texas A&M University | 28 | 6.40 | 1984 |
| 274 | Use of Antistripping Additives in Asphaltic Concrete - Laboratory Phase | David G. Tunnicliff | 50 | 7.60 | 1989 |
| 281 | Joint Repair Methods for Portland Cement Concrete Pavements - Design and Construction Guidelines | University of Illinois | 83 | 9.20 | 1985 |
| 284 | Evaluation of Procedures Used to Measure Cement and Water Content in Fresh Concrete | U.S. Army Corps of Engineers Waterways Experiment Station | 76 | 9.20 | 1986 |
| 290 | Reinforcement of Earth Slopes and Embankments | Dames & Moore | 323 | 40.00 | 1987 |
| 295 | Automated Field Survey Data Collection System | ARE Inc./Cooper Technology | 107 | 13.20 | 1987 |
| 310 | Dealing with Hazardous Waste Sites - A Compendium for Highway Agencies | HMM Associates | 107 | 12.00 | 1988 |
| 314 | Performance of Weathering Steel in Bridges | Sheladia Associates, Inc. | 98 | 16.00 | 1988 |
| 321 | Welded Repair of Cracks in Steel Bridge Members | The Welding Institute | 46 | 8.00 | 1989 |
| **(b) NCHRP Synthesis of Highway Practice (Project 20-5)** | | Transportation Research Board | | | |
| 2 | Bridge Approach Design and Construction Practices | | 30 | * | 1969 |
| 6 | Principles of Project Scheduling and Monitoring | | 43 | * | 1970 |
| 8 | Construction of Embankments | | 38 | * | 1971 |
| 9 | Pavement Rehabilitation - Materials and Techniques | | 41 | * | 1972 |
| 16 | Continuously Reinforced Concrete Pavement | | 23 | 2.80 | 1973 |
| 18 | Erosion Control on Highway Construction | | 52 | * | 1973 |
| 19 | Design, Construction, and Maintenance of PCC Pavement Joints | | 40 | * | 1973 |

* Out of print publications are available in microfiche from the Transportation Research Board. The cost is $8.00 per publication.

TABLE 3 - Continued

| No. | Title | Research Agency | Pages | Cost ($) | Year |
|---|---|---|---|---|---|
| **(b) NCHRP Synthesis of Highway Practice (Project 20-5), continued** | | Transportation Research Board | | | |
| 25 | Reconditioning High-Volume Freeways in Urban Areas | | 56 | 4.00 | 1974 |
| 27 | PCC Pavements for Low-Volume Roads and City Streets | | 31 | * | 1975 |
| 28 | Partial-Lane Pavement Widening | | 30 | 3.20 | 1975 |
| 29 | Treatment of Soft Foundations for Embankments (see Syn. 147) | | 25 | 3.20 | 1975 |
| 36 | Instrumentation and Equipment for Testing Highway Materials, Products, and Performance | | 70 | 4.80 | 1976 |
| 37 | Lime-Fly Ash-Stabilized Bases and Subbases | | 66 | * | 1976 |
| 38 | Statistically Oriented End-Result Specifications | | 40 | 4.00 | 1976 |
| 44 | Consolidation of Concrete for Pavements, Bridge Decks, and Overlays | | 61 | 4.80 | 1977 |
| 47 | Effect of Weather on Highway Construction | | 29 | 3.20 | 1978 |
| 51 | Construction Contract Staffing | | 62 | 6.00 | 1978 |
| 54 | Recycling Materials for Highways | | 53 | * | 1978 |
| 56 | Joint-Related Distress in PCC Pavement - Cause, Prevention, and Rehabilitation | | 36 | 5.20 | 1979 |
| 65 | Quality Assurance | | 42 | 5.60 | 1979 |
| 78 | Value Engineering in Preconstruction and Construction | | 23 | 6.40 | 1981 |
| 79 | Contract Time Determination | | 45 | 7.20 | 1981 |
| 85 | Energy Involved in Construction Materials and Procedures | | 34 | 6.40 | 1981 |
| 92 | Minimizing Reflection Cracking of Pavement Overlays | | 38 | 6.80 | 1982 |
| 99 | Resurfacing with Portland Cement Concrete | | 90 | * | 1982 |
| 102 | Material Certification and Material-Certification Effectiveness | | 17 | 6.00 | 1983 |
| 105 | Construction Contract Claims: Causes and Methods of Settlement | | 58 | 7.20 | 1983 |
| 115 | Reducing Construction Conflicts between Highways and Utilities | | 73 | 8.80 | 1984 |
| 127 | Use of Fly Ash in Concrete | | 66 | 8.40 | 1986 |
| 134 | D-Cracking of Concrete Pavements | | 34 | 7.60 | 1987 |
| 141 | Bridge Deck Joints | | 66 | 9.00 | 1989 |
| 144 | Breaking/Cracking and Sealing Concrete Pavements | | 39 | 8.00 | 1989 |
| 145 | Staffing Considerations in Construction Engineering Management | | 42 | 8.00 | 1989 |
| 146 | Use of Consultants for Construction Engineering and Inspection | | 64 | 9.00 | 1989 |
| 147 | Treatment of Problem Foundations for Highway Embankments | | 72 | 9.00 | 1989 |
| 150 | Technology Transfer in Selected Highway Agencies | | 38 | 8.00 | 1989 |
| 152 | Compaction of Asphalt Pavement | | 42 | 8.00 | 1989 |
| 154 | Recycling Portland Cement Concrete Pavements | | 46 | 8.00 | 1989 |
| 159 | Design and Construction of Bridge Approaches | | 45 | 8.00 | 1990 |
| 163 | Innovative Strategies for Upgrading of Personnel in State Transportation Departments | | 35 | 7.00 | 1990 |
| **(c) NCHRP Research Results Digest** | | | | | |
| 100 | Safe Conduct of Traffic Through Highway Construction and Maintenance Zones | Transportation Research Board | 5 | 1.00 | 1978 |
| 106 | Use of Waste Materials in Highway Construction and Maintenance | Transportation Research Board | 2 | 1.00 | 1979 |
| 121 | Development and Field Evaluation of Prototype Soil Moisture Sensors | Southwest Research Institute | | | 1979 |
| 123 | Evaluation of Preformed Elastomeric Pavement Joint Sealing Systems | Utah DOT | 7 | 1.00 | 1979 |
| 169 | Rapid Replacement of Portland Cement Concrete Pavement Segments | ARE Inc. | 11 | 4.00 | 1988 |
| 174 | Determinations of Water:Cement Ratio in Fresh Concrete | Wiss, Janney, Elstner Associates, Inc. | 3 | * | 1990 |

* Out of print publications are available in microfiche from the Transportation Research Board. The cost is $8.00 per publication.

TABLE 3 - Continued

| No. | Title | Research Agency | Pages | Cost ($) | Year |
|---|---|---|---|---|---|
| **(d) NCHRP Legal Research Digests** ** **(Project 20-6)** | | Transportation Research Board | | | |
| 2 | Supplement to Liability of State Highway Departments for Design, Construction, and Maintenance Defects | | 20 | 6.00 | 1988 |
| 4 | Supplement to Personal Liability of State Highway Department Officers and Employees | | 9 | 3.00 | 1988 |
| 5 | Supplement to Labor Standards in Federal-Aid Highway Construction Contracts | | 20 | 6.00 | 1989 |
| 7 | Liability of Public Agencies Arising Out of Rejection of Bids and Misaward of Contracts | | 17 | 6.00 | 1989 |
| 12 | Suspension, Debarment,and Disqualification of Highway Construction Contractors | | 27 | 6.00 | 1990 |
| 13 | Civil RICO (Racketeer Influenced and Corrupt Organizations Act) Applications in the Highway Construction Industry | | 28 | 6.00 | 1990 |
| 14 | Supplement to Liability of State Highway Departments for Defects in Design, Construction, and Maintenance of Bridges | | 12 | 6.00 | 1990 |

Copies of the publications listed in Table 3 may be obtained from the Business Office, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, DC 20418. A check or money order payable to the Transportation Research Board must accompany orders totaling $20.00 or less.

* Out of print publications are available in microfiche from the Transportation Research Board. The cost is $8.00 per publication.
** Supplements and new papers are also published periodically in an addendum to the 4-volume *Selected Studies in Highway Law*, also available from the Transportation Research Board.

TABLE 4 UNCORRECTED AGENCY FINAL REPORTS

| Proj. No. | Title | Year | Research Agency | Availability* |
|---|---|---|---|---|
| 3-32 | Temporary Pavement Markings for Work Zones | 1987 | Texas A&M Research Foundation | A |
| 4-13A | Temporary Pavement Marking Paint Systems | 1979 | Georgia Institute of Technology | A |
| 10-13 | Ultrasonic Measurement of Weld Flaw Size (Phase II) | 1985 | The Welding Institute (England) | A |
| 10-17 | Use of Antistripping Additives in Asphaltic Concrete Mixtures Phase II | 1989 | David G. Tunnicliff | A |
| 10-26 | Data Bases for Performance-Related Specifications for Highway Construction | 1984 | ARE Inc. | A & B |
| 12-34 | Update of AASHTO Standard Specifications for Highway Bridges Division 11 - Construction | 1989 | Imbsen & Associates, Inc. | Sent to AASHTO |
| 20-7 | Task 8 - Engergy and Transportation Systems | 1979 | California Dept. of Transportation | B |
| | Task 23 - Contracting Policies and Payment Procedures | 1984 | Bergstralh-Shaw-Newman, Inc. | A |
| 21-2(3) | Instrumentation for Moisture Measurement - Bases, Subgrades, and Earth Material (Sensor Evaluation) | 1979 | Southwest Research Institute | A |

* A--Copies of uncorrected drafts of the agencys' reports may be obtained on a loan basis by request to the Director, Cooperative Research Programs, Transportation Research Board.
B--Available in microfiche from the Transportation Research Board. The cost is $8.00 per report.

TABLE 5 AGENCY FINAL REPORTS RECEIVING SPECIAL TREATMENT

| Project Number | Title | Year | Research Agency | Available From |
|---|---|---|---|---|
| 20-7 | Task 18 - Standard Specifications for Highway Bridges | 1983 | Howard Needles Tammen & Bergendoff | AASHTO |
| | Task 32 - Design and Construction Specifications for Segmental Concrete Bridges | 1989 | Post-Tensioning Institute | AASHTO |
| | Task 41 - AASHTO Guide for Recruitment and Retention of Transportation Professionals | 1990 | Dr. Herb Golden | AASHTO |
| | Task 44 - Division 100 Revisions of the AASHTO Guide Specifications for Highway Construction | 1990 | Trauner Consulting Services, Inc. | Sent to AASHTO |