National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

DIGEST 155 - February 1986

Areas of Interest: 25 structures design and performance, 33 construction, 40 maintenance, 62 soil foundations (1 highway transportation, 2 public transit, 3 rail transportation)

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NCHRP Research on Bridge Engineering

An NCHRP staff digest of the progress and status of bridge engineering research under the National Cooperative Highway Research Program.

Since its inception in 1962 the National Cooperative Highway Research Program (NCHRP) has included numerous studies of interest to bridge engineers. In recent years, there has been a growing national awareness of bridge problems, and a substantial number of bridge research projects have been referred to NCHRP by the program sponsors, the American Association of State Highway and Transportation Officials (AASHTO), to the extent that in the past 6 years more than one-third of NCHRP's funds have been allocated for studies of problems in the area of bridge engineering.

Many of these studies have been directed to development of improved methods of design and construction, with the ultimate goal of modifying the AASHTO Standard Specifications for Highway Bridges, but, in recent years, an increasing amount of research has been aimed at problems in evaluation, repair, or rehabilitation of existing bridges.

About one-half of the approximately 600,000 highway bridges in the United States were built before 1940, and many have not been maintained adequately. Most bridges in service today were designed for less traffic, smaller vehicles, slower speeds, and lighter loads. In addition, deterioration caused by environmental contamination is a growing problem. Almost 40 percent of the Nation's bridges are classified, according to the Federal Highway Administration's (FHWA) criteria, as deficient and in need of rehabilitation or replacement. More than 100,000 of these are judged to be structurally deficient because of deterioration or distress, and another 100,000 are considered functionally obsolete or inadequate for current requirements. The cost of needed work on these deficient bridges is estimated at almost $50 billion.

It is clear, therefore, that engineers will have to contend with large numbers of deficient bridges for many years to come. Many urgent, researchable problems related to existing bridges remain to be solved. For example, practical, effective procedures and equipment need to be developed

and evaluated for use in the following areas: inspection of various types of bridge components, assessment of the effects of deterioration and distress, load rating, and estimating remaining life. In addition, research and development are needed on materials, equipment, and techniques for repair, rehabilitation, and reconstruction of bridge components built of various materials using various construction techniques with various loading and environmental conditions.

The magnitude of the effort required to deal with the Nation's deficient bridges is such that an investment in R&D resulting in an improvement of only 1% in the overall efficiency of performing this task will return something on the order of $500 million. The current, strong emphasis on bridge research in the NCHRP reflects AASHTO's recognition that, for bridge engineers to continue to do their part in expanding and maintaining the Nation's highway system in the face of limited resources, research will be necessary to find better methods of bridge design, construction, maintenance, repair, and rehabilitation.

The purpose of this Research Results Digest is to outline for easy reference (see Tables 1 through 4) the status of all NCHRP research related to bridges. Included are projects completed, in progress, and under development. A listing of all related research reports is also provided, with directions for obtaining copies. This digest supersedes RRD 143 published in February 1984.

NCHRP research covers a wide range of problem areas related to design, construction, and maintenance of bridges. Nevertheless, the studies listed comprise only a portion of all bridge research carried out in the United States in recent years. A more comprehensive listing of current and planned research, including FHWA-sponsored contracts and state Highway Planning and Research (HP&R) studies, can be found in the documentation for FHWA's Federally Coordinated Program for Research and Development (FCP), which may be obtained from Mr. Charles F. Galambos, Chief, Structures Division, Office of Research, Development & Technology, HNR-10, Federal Highway Administration, 6300 Georgetown Pike, McLean, Va 22101, 703/285-2087.

All NCHRP publications on bridge research are listed chronologically in Table 1. Some 54 relevant publications in the NCHRP Report series are included in Table 1(a). Several of the earlier reports, included for the sake of completeness, should no longer be considered to be thorough, up-to-date treatments of the subjects. NCHRP Syntheses of Highway Practice concerned with bridge problems are listed in Table 1(b). These reports emanate from NCHRP Project 20-5, "Synthesis of Information Related to Highway Problems." Table 1(c) includes NCHRP Research Results Digests on studies of bridge problems.

Copies of publications listed in Table 1 can be obtained from the Publications Office, Transportation Research Board, 2101 Constitution Avenue, NW, Washington, D.C. 20418. A check or money order payable to Transportation Research Board must accompany orders totaling $10.00 or less.

Uncorrected copies of agency reports listed in Table 2 can be obtained as noted in the table.

Bridge engineering research projects currently in progress are listed in Table 3. Details on these studies can be found in the NCHRP Summary of Progress Through 1985.

Research projects in the developmental stage or expected to start in the near future are listed in Table 4.

TABLE 1 - REPORTS AVAILABLE

No.	Title	Proj. No.	Research Agency	No. of Pages	Cost	Year
			(a) NCHRP Report			
1*	Evaluation of Methods of Replacement of Deteriorated Concrete in Structures	6-8	Bertram D. Tallamy Associates	56	*	1964
4*	Non-Chemical Methods of Snow and Ice Control on Highway Structures	6-2	Roy Jorgensen and Associates	74	*	1964
16*	Protective Coatings to Prevent Deterioration of Concrete by Deicing Chemicals	6-3	Battelle Memorial Institute	21	*	1965
23*	Methods for Reducing Corrosion of Reinforcing Steel	6-4	Battelle Memorial Institute	22	*	1966
74	Protective Coatings for Highway Structural Steel	4-6	Steel Structures Painting Council	64	2.80	1969
74A*	Protective Coatings for Highway Structural Steel--Literature Survey	4-6	Steel Structures Painting Council	275	*	1969
74B*	Protective Coatings for Highway Structural Steel--Current Highway Practices	4-6	Steel Structures Painting Council	102	*	1969
80*	Oversize-Overweight Permit Operation on State Highways	2-10	Roy Jorgensen and Associates	120	*	1969
83*	Distribution of Wheel Loads on Highway Bridges	12-2	Iowa State University	56	*	1970
86*	Tentative Service Requirements for Bridge Rail Systems	12-8	Texas A & M University	62	*	1970
90	Protection of Steel in Prestressed Concrete Bridges	12-5	University of Denver	86	4.00	1970
101*	Effect of Stress on Freeze-Thaw Durability of Concrete Bridge Decks	6-9	University of Illinois	70	*	1970
102	Effect of Weldments on the Fatigue Strength of Steel Beams	12-7	Lehigh University	114	5.40	1970
105*	Dynamic Pavement Loads of Heavy Highway Vehicles	15-5	General Motors Corporation	94	*	1970
106*	Revibration of Retarded Concrete for Continuous Bridge Decks	18-1	University of Illinois	67	*	1970
109*	Elastomeric Bearing Research	12-9	Battelle Memorial Institute	53	*	1970
116*	Structural Analysis and Design of Pipe Culverts	15-3	Northwestern University	155	*	1971
141*	Changes in Legal Vehicles Weights and Dimensions: Some Economic Effects on Highways	19-3	Wilbur Smith and Associates	184	*	1973
147	Fatigue Strength of Steel Beams with Welded Stiffeners and Attachments	12-7	Lehigh University	85	4.80	1974
149	Bridge Rail Design—Factors, Trends, and Guidelines	12-8	Texas A & M University	49	4.00	1974
153	Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances	22-2	Southwest Research Institute	19	3.20	1974
163	Design of Bent Caps for Concrete Box-Girder Bridges	12-10	Portland Cement Association	124	6.80	1976
164	Fatigue Strength of High-Yield Reinforcing Bars	4-7	Portland Cement Association	90	5.60	1976
165	Waterproof Membranes for Protection of Concrete Bridge Decks--Laboratory Phase	12-11	Materials Research and Development	70	4.80	1976
180*	Cathodic Protection for Reinforced Concrete Bridge Decks	12-13	USS Engineers and Consultants	135	*	1977
181	Subcritical Crack Growth in Steel Bridge Members	12-14	U. S. Steel Corporation	82	5.60	1977
182	Economic Evaluation of Ice and Frost	6-11	Midwest Research Institute	73	4.80	1978
188	Fatigue of Welded Steel Bridge Members Under Variable Amplitude Loadings	12-12	U. S. Steel Corporation	113	6.40	1978
190*	Use of Polymers in Highway Concrete	18-2	Lehigh University	77	*	1978
198	State Laws and Regulations on Truck Size and Weight	20-16	R. J. Hansen Associates	117	7.20	1979
201	Acceptance Criteria for Electroslag Weldments in Bridges	10-10	U. S. Steel Corporation	44	5.20	1979
203	Safety at Narrow Bridge Sites	20-7 Task 7	Texas A & M University	63	6.00	1979
204	Bridge Deck Joint-Sealing Systems-Evaluation and Performance Specification	10-11	Howard Needles Tammen & Bergendoff	46	5.60	1979
206	Detection and Repair of Fatigue Damage in Welded Highway Bridges	12-15 & 12-15(2)	Lehigh University	85	6.80	1979
222	Bridges on Secondary Highways and Local Roads-Rehabilitation and Replacement	12-20	University of Virginia	132	9.20	1980
226	Damage Evaluation and Repair Methods for Prestressed Concrete Bridge Members	12-21	G. O. Shanafelt & W. B. Horn	66	7.20	1980
227	Fatigue Behavior of Full-Scale Welded Bridge Attachments	12-15(3)	Lehigh University	47	6.40	1980
230	Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances	22-2(4)	Southwest Research Institute	42	6.00	1981
234	Galvanic Cathodic Protection for Reinforced Concrete Bridge Decks-Field Evaluation	12-13A	Portland Cement Association	64	6.80	1981
239	Multiple-Service-Level Highway Bridge Railing Selection Procedures	22-2(3)	Southwest Research Institute	161	10.40	1981
240	A Manual to Determine Benefits of Separating Pedestrians and Vehicles	20-10(2)	SRI Internation	56	7.20	1981

TABLE 1 - continued

No.	Title	Proj. No.	Research Agency	No. of Pages	Cost	Year
242	Ultrasonic Measurement of Weld Flaw Size	10-13	The Welding Institute England	76	8.00	1981
243	Rehabilitation and Replacement of Bridges on Secondary Highways and Local Roads	12-20	University of Virginia	46	6.80	1981
244	Concrete Sealers for Protection of Bridge Structures	12-19A	Wiss, Janney, Elstner & Associates, Inc.	138	10.00	1981
248	Elastomeric Bearings Design, Construction, and Materials	10-20	University of Washington	82	8.40	1982
251	Assessment of Deficiencies and Preservation of Bridge Substructures Below the Waterline	10-16	Byrd, Tallamy, MacDonald and Lewis	80	8.40	1982
257	Long-Term Rehabilitation of Salt-Contaiminated Bridge Decks	18-2(3)	Lehigh University	32	6.40	1983
265	Removal of Lead-Based Bridge Paints	10-23	Midwest Research Institute	72	8.00	1983
267	Steel Bridge Members Under Variable Amplitude Long Life Fatigue Loading	12-15(4)	Lehigh University	26	6.40	1983
271	Guidelines for Evaluation and Repair of Damaged Steel Bridge Members	12-17A	G.O. Shanafelt and W.B. Horn	64	7.60	1984
272	Performance of Weathering Steel in Bridges	10-22	Sheladia Associates, Inc.	164	12.00	1984
276	Thermal Effects in Concrete Bridge Superstructures	12-22	Engineering Computer Corporation	**	**	1985
278	Cathodic Protection of Concrete Bridge Substructures	12-19B	Wiss, Janney, Elstner Associates, Inc.	60	8.40	1985
280	Guidelines for Evaluation and Repair of Damaged Prestressed Concrete Bridge Members	12-21(1)	G.O. Shanafelt and W.B. Horn	**	**	1985
			(b) NCHRP Synthesis of Highway Practice			
2*	Bridge Approach Design and Construction Practices	20-5 Topic #2	Transportation Research Board	30	*	1969
4*	Concrete Bridge Deck Durability	#3	Transportation Research Board	28	*	1970
5*	Scour at Bridge Waterways	#5	Transportation Research Board	28	*	1970
33	Acquisition and Use of Geotechnical Information	#5-04	Transportation Research Board	40	4.00	1976
41	Bridge Bearings	#6-09	Transportation Research Board	62	4.80	1977
42	Design of Pile Foundations	#5-04	Transportation Research Board	68	4.80	1977
44	Consolidation of Concrete for Pavements, Bridge Decks, and Overlays	#7-01	Transportation Research Board	61	4.80	1977
50	Durability of Drainage Pipe	#5-09	Transportation Research Board	37	3.60	1978
53	Precast Concrete Elements for Transportation Facilities	#8-05	Transportation Research Board	48	5.60	1978
57	Durability of Concrete Bridge Decks	#9-01	Transportation Research Board	61	6.00	1979
67	Bridge Drainage Systems	#10-06	Transportation Research Board	44	5.60	1979
68	Motor Vehicle Size and Weight Regulations, Enforcement, and Permit Organizations	#10-04	Transportation Research Board	45	6.00	1980
78	Value Engineering in Preconstruction and Construction	#11-02 & 03	Transportation Research Board	23	6.40	1981
82	Criteria for Evaluation of Truck Weight Enforcement Programs	#12-02	Transportation Research Board	74	7.20	1981
86	Effects of Traffic-Induced Vibrations on Bridge-Deck Repairs	#10-21	Transportation Research Board	40	6.80	1981
88	Underwater Inspection and Repairs of Bridge Substructures	#10-08	Transportation Research Board	77	7.60	1981
101	Historic Bridges: Criteria for Decision Making	#13-11	Transportation Research Board	84	8.00	1983
107	Shallow Foundations for Highway Structures	#12-06	Transportation Research Board	38	6.80	1983
108	Bridge Weight-Limit Posting Practice	#13-08	Transportation Research Board	30	6.40	1984
111	Distribution of Wheel Loads on Highway Bridges	#14-22	Transportation Research Board	22	7.20	1984
112	Cost-Effectiveness of Hot-Dip Galvanizing for Exposed Steel	#15-19	Transportation Research Board	28	7.20	1984
118	Detecting Defects and Deterioration in Highway Structures	#15-03	Transportation Research Board	52	8.00	1985
119	Prefabricated Bridge Elements and Systems	#15-10	Transportation Research Board	75	8.80	1985
123	Bridge Designs to Reduce and Facilitate Maintenance and Repair	#12-11	Transportation Research Board	**	**	1985
			(c) NCHRP Research Results Digest			
81	Crash Testing and Evaluation of Attenuating Bridge Railing System	22-1A	Texas A & M University	10	1.00	1976
85	Bridge Deck Repairs	12-16	Battelle Columbus Laboratory	22	1.00	1976
115	NCHRP Research on the Durability of Reinforced Concrete Bridge Components	Var.	Transportation Research Board	6	1.00	1979
141	Liability of State Highway Departments for Defects in Design, Construction, and Maintenance of Bridges	20-6	Transportation Research Board	30	3.00	1983

* Out of print - Available in microfiche from the Transportation Research Board
The cost is $5.00 per publication
** In publication - Available in early 1986.

TABLE 2 - UNCORRECTED AGENCY FINAL REPORT

Proj. No.	Title	Research Agency	Avail-ability*
4-14	Coating Systems for Painting Old and New Structural Steel	Georgia Institute of Technology	A & B
10-15	Structural Strength Evaluation of Existing Reinforced Concrete Bridges (Phase II)	Engineering Computer Corporation	B
12-1	Deformation of Steel Beams Related to Permitted Highway Bridge Overloads	University of Missouri	B
12-4	Thermal Characteristics of Highway Bridges	Southwest Research Institute	B
12-6	Prediction of Permanent Camber of Bridges	University of Missouri	B
12-11/1	Waterproof Membrances for Protection of Concrete Bridge Decks	Materials R & D	A & B
12-15	Detection and Repair of Fatigue Cracking in Highway Bridges	Lehigh University	B
12-15(2)	Retrofitting Procedures for Fatigue-Damaged Full-Scale Welded Bridge Beams	Lehigh University	B
12-16	Influence of Bridge Deck Repairs on Corrosion of Reinforcing Steel	Battelle Columbus Laboratories	A & B
12-17	Evaluation of Repair Techniques for Damaged Steel Bridge Members	Battelle Columbus Laboratories	B
12-18	Development of an Integrated Bridge Design System (Interim)	Multisystems, Inc.	A & B
12-19	Corrosion Control and Repair of Concrete Bridge Structures (Interim)	Corrosion Eng. & Research Co.	A & B
12-19	Cathodic Protection of Concrete Bridge Structures	Corrosion Eng. & Research Co.	A & B
18-2(2)	Polymer Concrete in Highway Bridge Decks	Lehigh University	A & B
22-1	Concepts for Improved Traffic Barrier Systems	Walter W. White	B
22-1A	Testing and Evaluation of Bridge Rail Concepts	Texas A&M University	B
22-2(2)	Multiple Service Level Highway Bridge Railings--Performance and Design Criteria (Phase 1)	Southwest Research Institute	B
22-2(2)	Multiple Service Level Highway Bridge Railings--Development and Evaluation of Low-Cost Railing System (Phase II)	Southwest Research Institute	B

* A: A copy of the uncorrected draft of the agency's report may be obtained on a loan basis by request to the Director, Cooperative Research Programs.
B: Available in microfiche from the Transportation Research Board. The cost is $5.00 per publication.

TABLE 3 - RESEARCH IN PROGRESS

Proj. No.	Title	Research Agency	Completion Date
4-15	Corrosion Protection of Prestressing Systems in Concrete	Wiss, Janney, Elstner Associates, Inc.	5/31/86
10-13/1	Ultrasonic Measurement of Weld Flaw Size	The Welding Institute	*
10-15/1	Structural Strength Evaluation of Existing Reinforced Concrete Bridges	Engineering Computer Corporation	4/30/86
10-20/1	Elastomeric Bearings Design, Construction, and Materials	University of Washington	5/31/86
10-22/1	The Performance of Weathering Steel in Bridges	Sheladia Associates, Inc.	4/22/86
10-29	Anchorage Zone Reinforcement for Post-Tensioned Concrete Girders	University of Texas at Austin	4/14/89
10-30(1)	Nondestructive Methods for Field Inspection of Embedded or Encased High Strength Steel Rods and Cables	University of Manchester, Institute of Science & Technology	8/6/86
10-30(2)	Nondestructive Methods for Field Inspection of Embedded or Encased High Strength Steel Rods and Cables	Southwest Research Institute	8/6/86
10-31	Acceptance Criteria for Steel Bridge Welds	Materials Research Laboratory, Inc.	12/31/88
12-15(5)	Fatigue Behavior of Variable Loaded Bridge Details Near the Fatigue Limit	Lehigh University	8/31/87
12-18A	Assessment of an Integrated Bridge Design System	Engineering Computer Corporation	*
12-24	Design of Multi-Beam Precast Bridge Superstructures	University of Michigan	5/31/86
12-25	Fatigue and Fracture Evaluation for Rating Riveted Steel Bridges	Lehigh University	3/31/87
12-26	Distribution of Wheel Loads on Highway Bridges	Engineering Computer Corporation	7/15/87
12-27	Welded Repair of Cracks in Steel Bridge Members	The Welding Institute	10/14/87
12-28(1)	Load Capacity Evaluation of Existing Bridges	Case Western Reserve University	8/31/87
12-28(2)	Bridge Management Systems	ARE Inc	6/23/87
12-28(3)	Fatigue Evaluation Procedures for Steel Bridges	Case Western Reserve University	6/30/87
12-28(4)	Methods of Strengthening Existing Highway Bridges	Iowa State University	12/31/86
12-28(5)	Standard Methodology for Conducting Condition Surveys of Concrete Bridge Components	New Mexico State University	1/31/87
12-28(6)	Distortion-Induced Fatigue Cracking in Steel Bridges	Lehigh University	9/30/88
12-28(7)	Guidelines for Evaluating Corrosion Effects in Existing Steel Bridges	Modjeski and Masters	1/31/89
12-28(8)	Improving Bridge Load Capacity Estimates by Correlation with Test Data	University of Tennessee, Transportation Center	12/31/87
12-28(10)	Guidelines for Determining Redundancy in Steel Bridges	Lehigh University	8/31/88
12-29	Design of Simple-Span Precast Prestressed Bridge Girders Made Continuous	Construction Technology Laboratories	11/25/87
12-30	Fatigue of Cables in Cable-Stayed Bridges	Freeman Fox Ltd.	10/12/87
12-32	Evaluation of Bridge Deck Protective Strategies	University of Washington	3/31/89
20-5	Synthesis of Information Related to Highway Problems Topic 9-12, Welding and Inspection Practices in Bridge Fabrication Topic 15-02, Durability of Prestressed Concrete Highway Structures Topic 15-09, Protective Coatings for Bridge Steel Topic 16-01, Bridge Inspection Practices-Equipment, Staffing, and Safety Topic 16-02, Use of Weigh-In-Motion Systems for Data Collection & Enforcement Topic 16-05, Freezing and Thawing Resistance of High-Strength Concrete Topic 16-07, Use of Fly Ash in Concrete Topic 16-10, Bridge Expansion Devices Topic 17-04, Effectiveness of Quality Assurance Procedures for Highway Construction and Materials	Transportation Research Board	Variable
20-20(6)	Detailed Planning for SHRP Research on Bridge Component Protection	David G. Manning	1/31/86
24-3	Laboratory Evaluation of Piles Installed with Vibratory Drivers	University of Houston	1/5/88

* Final Report in Review Process

TABLE 4 - PENDING RESEARCH

Project Number	Title	Funds Available	Expected Start
3-36	Development of a Low-Cost Bridge Weigh-In-Motion System	400,000	Early 1987
4-15	Corrosion Protection of Prestressing Systems in Concrete (Phase II)	100,000	Mid 1986
10-20	Elastomeric Bearings Design, Construction and Materials (Phase III)	150,000	Mid 1986
10-29	Anchorage Zone Reinforcement for Post-Tensioned Concrete Girders (Phase II)	250,000	Mid 1987
10-30	Nondestructive Methods for Field Inspection of Embedded or Encased High Strength Steel Rods and Cables (Phase II)	150,000	Late 1986
10-35	Fatigue Behavior of Welded and Mechanical Splices in Reinforcing Steel	300,000	Early 1987
12-28(2)	Bridge Management Systems (Phase II)	250,000	Mid 1987
12-28(9)	Methods of Flaw Detection in Concrete Bridge Components	250,000	Late 1986
12-28(11)	Development of Bridge Load Spectra for Rating	200,000	Early 1987
12-28(12)	Inelastic Rating Procedures for Steel Bending Members with Full or Partial Continuity	250,000	Early 1987
12-28(13)	Nondestructive Load Testing in the Bridge Evaluation and Rating Process	150,000	Early 1987
12-31	Study of Impact Resistant Bridge Steels	375,000	Late 1986
12-32	Evaluation of Bridge Deck Protective Strategies (Phase II)	100,000	Mid 1987
15-11	Hydraulic Analysis of Bridges on Streams with Movable Beds and Banks	350,000	Early 1987
24-4	Development of Load Factor Design Criteria for Foundation Systems	500,000	Early 1987
20-5	Synthesis of Information Related to Highway Problems Topic 18-03 - Bridge Abutment and Approach Design Topic 18-13 - Surface Preparation for Concrete Repairs Topic 18-15 - Epoxy-Coated Reinforcing Steel: Guidelines for Production, Storage, and Use		

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