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ANNUAL REPORT
Of
HIGHWAY RESEARCH
And
DEVELOPMENT
In
IOWA



**Iowa Department
of Transportation**

HIGHWAY DIVISION
OFFICE OF MATERIALS
DECEMBER 1982

ANNUAL REPORT
OF
HIGHWAY RESEARCH AND DEVELOPMENT IN IOWA

FOR THE
FISCAL YEAR ENDING JUNE 30, 1982

OFFICE OF MATERIALS
(515)239-1447

HIGHWAY DIVISION
IOWA DEPARTMENT OF TRANSPORTATION
AMES, IOWA 50010

DECEMBER 1982

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RESEARCH AND DEVELOPMENT

The Highway Division of the Iowa Department of Transportation engages in research and development for two reasons: first, to find workable solutions to the many problems that require more than ordinary, routine investigation; and second, to identify and implement improved engineering and management practices.

This report entitled, "Highway Research and Development in Iowa", is submitted in compliance with Section 310.36, Code of Iowa, which directs the submission of a report of the Secondary Road Research Fund. It is a report on the status of research and development projects which were in progress on June 30, 1982; it is also a report on projects completed during the fiscal year beginning July 1, 1981, and ending June 30, 1982. Detailed information on each of the research and development projects mentioned in this report is available in the Office of Materials, Highway Division, Iowa Department of Transportation.

IOWA HIGHWAY RESEARCH BOARD

In developing a progressive, continuing, coordinated program of research and development, the Highway Division is assisted by the Iowa Highway Research Board. This advisory group was established in 1949 by the Iowa State Highway Commission to respond to the research denoted in Section 310.36 of the Code of Iowa.

The Research Board consists of 13 regular members; six county engineers, three DOT Highway Division engineers, one representative from Iowa State University, one from the University of Iowa, and two engineers employed by Iowa municipalities. Each regular member may have an alternate who will serve at the request of the regular member. The regular members and their alternates are appointed by the Iowa Department of Transportation Highway Division Director for a three-year term. The membership of the Research Board as of June 30, 1982, is listed in Table 1.

The Research Board held eight regular meetings during the period of July 1, 1981 to June 30, 1982. Suggestions for research and development were reviewed at these meetings and recommendations were made by the Board.

1982
IOWA HIGHWAY RESEARCH BOARD

MEMBER	TERM EXPIRES	ALTERNATE
W. W. Amundson Director of Public Works Box 447 Sioux City, IA 51100 (712)279-6111	12-31-82	R. Holland City Engineer Bettendorf, IA 52722 (319)359-0347
F. O. Bloomfield Right-of-Way Director Iowa DOT-Highway Division Ames, IA 50010 (515)239-1149	12-31-82	C. L. Huisman Materials Engineer Iowa DOT-Highway Division Ames, IA 50010 (515)239-1452
D. R. Boylan, Dean College of Engineering Iowa State University Ames, IA 50011 (515)294-5933	12-31-82	P. W. Peterson Associate Dean of Research Iowa State University 104 Marston Hall Ames, IA 50011 (515)294-2336
G. Calvert Deputy Director, Development Iowa DOT-Highway Division Ames, IA 50010 (515)239-1461	12-31-82	T. E. McElherne Specifications Engineer Iowa DOT-Highway Division Ames, IA 50010 (515)239-1566
P. Dvorak Grundy County Engineer Grundy Center, IA 50638 (319)824-6912	12-31-84	R. Gumbert Tama County Engineer Toledo, IA 52342 (515)484-3341
R. G. Hering Dean of Engineering University of Iowa Iowa City, IA 52242 (319)353-6603	12-31-84	H. Kane, Chairman Civil & Env. Engr. Program University of Iowa Iowa City, IA 52242 (319)353-4968
R. Kirchner City Engineer Fort Dodge, IA 50501 (515)576-3601	12-31-83	W. J. Schreiner City Engineer Ankeny, IA 50021 (515)964-5500
N. Konrady Lucas County Engineer Chariton, IA 50049 (515)774-4013	12-31-83	R. Simmering Muscatine County Engineer Muscatine, IA 52761 (319)263-6351
D. D. Linnan Buena Vista County Engineer Storm Lake, IA 50588 (712)732-1519	12-31-82	R. Michaelis Carroll County Engineer Carroll, IA 51401 (712)792-3603
D. J. Lynam Adair County Engineer Greenfield, IA 50849 (515)743-6111	12-31-84	C. Christensen Fremont County Engineer Sidney, IA 51652 (712)374-2613
L. Mattusch Clinton County Engineer Clinton, IA 52732 (319)243-6210	12-31-82	G. D. Petermeir Benton County Engineer Vinton, IA 52349 (319)472-2211
W. A. Moellering Fayette County Engineer West Union, IA 52175 (319)422-3342	12-31-83	N. Jorgensen Franklin County Engineer Hampton, IA 50441 (515)466-4671
R. F. Percival District 5 Engineer Iowa DOT-Highway Division Fairfield, IA 52556 (515)472-4171	12-31-84	V. R. Snyder District 4 Engineer Iowa DOT-Highway Division Atlantic, IA 50022 (712)243-3355

RESEARCH AND DEVELOPMENT PROJECTS

Proposals for research and development are reviewed by the Iowa Highway Research Board, and its recommendations are transmitted to the Director of the Highway Division and the Director of the Department of Transportation. Expenditure of funds for research and development is then authorized on an individual project basis.

These expenditures may be charged to the Primary Road Fund or the Farm-to-Market Road Fund, depending on which road system will benefit from the project. If both primary and secondary roads share in the benefits, then the costs are shared.

Table II is a record of expenditures for research and development made during the fiscal year ending June 30, 1982. Total expenditure was \$640,830.09, including support of the National Cooperative Highway Research Program (see page 5).

IN-HOUSE RESEARCH AND DEVELOPMENT

Research and development projects performed by Highway Division personnel are termed "in-house" projects. These projects may involve other departmental and district personnel, in addition to personnel from the Office of Materials, Research Section. In many instances, personnel from other offices are designated as principal investigators, which means that they have a major role in the planning, performance and analysis of the research.

Contract research funds may be used for material and equipment costs for in-house research, but cannot be used for salary or personal expenses of the participating personnel. Consequently, the contract amounts shown for in-house projects are relatively small and the Office of Materials, Research Section, wishes to express its appreciation to other offices and districts for their assistance.

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

The National Cooperative Highway Research Program (NCHRP) was organized by the American Association of State Highway Officials (now the American Association of State Highway and Transportation Officials -- AASHTO). The program is administered by the Transportation Research Board, a branch of the National Academy of Science.

The purpose of NCHRP is to provide the funds and direction for research in highway matters of national concern.

The program is funded annually by all of the states in an amount equal to 0.0675 percent of the federal aid allocated to the states for highways. Iowa's obligation and actual expenditure for NCHRP varies and may be influenced by billing practices.

SECONDARY ROAD RESEARCH FUND

Section 310.34 of the Iowa Code authorizes the Iowa Department of Transportation to set aside each year an amount not to exceed $1\frac{1}{2}$ percent of the receipts in the Farm-to-Market Fund in a fund to be known as the Secondary Road Research Fund. This authorization was first made in 1949, it was repealed in 1963 and reinstated in 1965. When the fund was reinstated, the use was designated to finance engineering studies and research projects. A summary of research and development expenditures from the Secondary Road Research Fund is itemized in Table II.

The values shown in Table II are actual research expenditures for fiscal year 1981. The Office of Transportation Inventory engineering studies include traffic counts and secondary road inventories. The Iowa Department of Transportation accounting procedure for the Secondary Road Research Fund is based on obligations for expenditures on research projects and not the actual expenditure. The Fiscal Year 1981 financial summary is.

Beginning Balance 7-1-81		\$1,074,028
Receipts		
Interest	\$ 68,507	
Fed. Sec. Rd.		
($1\frac{1}{2}\%$ of receipts) ...	165,569	
State RUTF ($1\frac{1}{2}\%$ of receipts)	477,785	
External Research Income	139,690	
Sub-Total		<u>851,551</u>
Total Funds Available		<u>\$1,925,579</u>
Obligation for Expenditures		
Obligated for		
Contract Research ...	751,999	
Non-Contract		
Engineering Studies ...	<u>37,322</u>	
Total Expenditures		<u>789,321</u>
BALANCE 6-30-82		\$1,136,258

SECONDARY ROAD TRAFFIC COUNT PROGRAM

During fiscal year 1982 the traffic count program conducted by the Office of Transportation Inventory on the Secondary Road System in 25 counties required a total of 2,800 four-hour manual counts. The traffic data from these counts was used to develop motor vehicle traffic flow maps for each county showing the average annual daily traffic (ADT) on specific road sections in each county. A secondary road inventory was completed in 14 counties. This data provides the county engineer, highway engineer, planner and administrator with essential information needed to determine design standard, systematic classification of highways and the development of programs for improvement and maintenance of secondary roads.

This traffic data is also added to the Iowa Department of Transportation's Secondary Road Base Record. This record is utilized for the preparation of numerous reports and studies including the annual vehicle miles of travel, mileage summaries, need studies, special studies, accident analysis, etc.

FINANCIAL SUMMARY OF RESEARCH AND DEVELOPMENT PROJECTS

July 1, 1981 to June 30, 1982

Project	Total Funds Committed	Primary Road Research Fund Expenditures	Secondary Road Research Fund Expenditures	Total Expenditures
140	48,410	24,205.00	24,205.00	48,410.00
173	10,060		6,035.00	6,035.00
176	50,000			
181	8,143			
186	172,085	17,038.00	2,013.93	19,051.93
188	50,000			
192	3,340			
198	75,000			
199	100,000			
203	51,000			
205	3,150			
206	2,510			
208A	137,725	14,505.42	46,525.42	61,030.84
209	100,347			
210	30,072			
211	149,114		40,656.19	40,656.19
213	13,550	204.60		204.60
214	58,895	4,314.06	3,434.55	7,748.61
215	10,700			
216	156,289			
217	43,000			
219	11,200			
220	8,000			
221	40,465		14,939.54	14,939.54
222	17,500			
224	8,000	3.75		3.75
225	89,600	16,236.45	18,346.24	34,582.69
226	44,000		9,240.72	9,240.72
227	34,855	9,861.31	13,637.11	23,498.42
228	48,540	4,406.88	270.73	4,677.61
229	130,000		92,430.00	92,430.00
230	56,305		20,057.93	20,057.93
231	45,340			
232	4,105			
233	138,405		7,652.64	7,652.64
234	5,000			
235	49,850	10,106.04	32,012.65	42,118.69
236	88,143			
237	87,065			
238	70,228	13,727.62	19,300.76	33,028.38
239	80,000		30,494.26	30,494.26
240	88,000			
241	8,500		159.00	159.00
243	3,445	3,133.66		3,133.66
244	9,700			
245	1,000	251.22	223.79	475.01
246	118,000			
247	88,260			
1027	30,000/yr.		33,036.15	33,036.15
Sub-Total		\$117,994.01	\$414,671.61	\$532,665.62
HPR-1(88) NCHRP		14,584.77	2,131.68	16,716.45
HPR-1(89) NCHRP		36,883.03	5,520.57	42,403.60
HPR-1(90) NCHRP		15,297.48	2,388.80	17,686.28
HPR-2(120) NCHRP		1,871.63	297.51	2,169.14
HPR-PR-PL-1(17) 1981 Planning & Research Program			29,189.00	29,189.00
TOTAL		\$186,630.92	\$454,199.17	\$640,830.09

RESEARCH PROJECT DESCRIPTIONS

The following portion of this report briefly describes research projects for which open files were maintained in the Office of Materials, Research Section during all or part of the fiscal year beginning July 1, 1981, and ending June 30, 1982. An open file for each project is maintained from the project's inception to completion; completion is signified by the acceptance of the final report and making the final payment. Each project description contains an implementation statement of the use now being made, or expected as a result of the research effort.

Project Number: HR-140

Project Title: Collection and Analysis of Stream Flow Data

Agency: Iowa City Office, Water Resources Division, United States Geological Survey, Department of Interior

Principal Investigator: J. J. Klein, U.S.G.S.

Research Period: Project continued to September 30, 1982, by approval of the Director-Highway Division

Research Funding: \$48,410 per year (matched by \$48,410 from the Department of the Interior)

Funding Source: 100 percent State funds--50 percent Primary, 50 percent Farm-to-Market

Iowa DOT Project Control: Mark F. Looschen, Bridge Design

Objectives: The objectives of Project HR-140 are to obtain information about the flow of water in Iowa streams with particular emphasis on the magnitude and frequency of floods and to compile and analyze this information for use by highway engineers engaged in the design of bridges, culverts and embankments.

Progress: The Water Resources Division employs a staff of engineers and technicians who monitor and maintain a network of stream gaging stations on Iowa streams. These measurements, along with data from special studies of selected streams and floods, are compiled and analyzed to form the basis for predictions of future streamflow. The progress during 1981-1982 was in accordance with schedules established by the Water Resources Division.

Reports: Periodically, a summary report of magnitude and frequency of Iowa floods is prepared. Reports of selected floods are also available.

Implementation: The information obtained from Project HR-140 is used daily by DOT personnel in the design of bridges and culverts.

Project Number: HR-173

Project Title: A Computer Based Information System for County Equipment Cost Records

Agency: Iowa Department of Transportation, Highway Division

Principal Investigators: S. Johnson, J.K. Poyzer, J.D. Poyzer

Research Period: December 7, 1981, to April 30, 1982

Research Funding: \$10,060

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To enhance the current "Computer Based Information System for County Equipment Cost Records" so it provides more accurate and more timely reports to county engineers who use it.

Progress: A contract for services was negotiated with James Poyzer, a programmer/analyst from Des Moines. Co-principal investigator is John Poyzer who worked on the original programs in 1975. The programs have been revised to allow for easy access to update and correct improper data entries. Also, the programs have been changed to accept individual county data for processing and to allow for several runs of data during the year. Several other minor changes are being initiated to make the program more responsive to the counties' needs. The program will be run this fall to test the improvements.

Reports: None

Implementation: Problems with the original program for county equipment cost records have made the output data unreliable for some counties. Program changes will allow for easy input of county equipment cost information and will result in much quicker return of accurate output data to the counties so the most cost-effective equipment can be identified and specified for future purchases.

Project Number: HR-176

Project Title: Recycled Asphalt Pavement

Agency: Kossuth County and Iowa Department of Transportation, Highway Division

Principal Investigator: R. Schiek, Kossuth County

Research Period: May 1, 1975, to March 30, 1982

Research Funding: \$50,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To conserve materials and establish techniques that will lead to more economical reconstruction of asphalt paving.

Progress: Construction of the proposed project was completed during the summer of 1975. Road Rater testing and friction testing has been completed on the road annually.

Reports: Final Report, April 1982

Implementation: This project proved recycling of asphalt concrete is feasible and additional research was needed to solve related problems. Research project HR-1008 was constructed in 1976 due to recommendations resulting from this project. In 1977 research project HR-188 established asphalt recycling as a viable method of construction that will conserve energy and materials. Kossuth County has accepted recycled asphalt pavement as a standard reconstruction practice.

Project Number: HR-181

Project Title: The Evaluation of Macadam Stone Shoulders

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R.A. Shelquist, Materials

Research Period: May 25, 1976, to September 30, 1981

Research Funding: \$8,143

Funding Source: 100 percent State--Primary funds

Objective: To determine the feasibility of using a macadam stone shoulder in place of the standard paved shoulder; to determine if there are any major problems associated with the construction and maintenance of macadam stone shoulders; and to evaluate the performance of macadam stone shoulders.

Progress: This experimental type of shoulder construction was incorporated into a Dallas County project on U.S. 6. Shoulder construction operations were observed and methods and procedures were recorded. The shoulder construction work was completed in 1977. Visual observations showed the shoulders with the asphalt concrete surface were performing well with no apparent surface deterioration. The side with the cover aggregate seal has some damage and open surface. Structural number comparisons between macadam shoulders and recently constructed stabilized and paved shoulders were made.

Reports: Final Report, September 1981

Implementation: This project will provide an alternate cost effective shoulder design for high traffic volume roadways.

Project Number: HR-186

Project Title: Evaluation of Changes in Productivity Resulting from Removal of Soil for Highway Construction

Agency: Iowa State University

Principal Investigator: S.J. Henning, Iowa State University

Research Period: January 1, 1977, to December 31, 1982

Research Funding: \$172,085

Funding Source: 100 percent State funds--75 percent Primary, 25 percent Farm-to-Market

Objective: To evaluate changes in soil productivity caused by removal of soil, to measure the effect on crop yields of returning surface soil under varying conditions and various tillage practices, and to determine the effects of land surface elevation above drainage tile or perched water tables.

Progress: Four borrow pit sites were obtained in Audubon, Buchanan, Hamilton, and Lee counties. These four locations were representative of the range of soil conditions present in Iowa. Corn, soybeans, and alfalfa plots were planted with various top soil replacement and ground preparations. Crop yields resulting from the various conditions have been compared. Research on the Audubon, Buchanan and Lee county sites has been completed. Research on the Hamilton County site will continue at least through the 1982 crop season.

Reports: Summary Report, February 1982

Implementation: Following completion of the project, a manual of practices and procedures for selection and treatment of borrow areas will be prepared.

Project Number: HR-188

Project Title: Evaluation of Air Pollution Control Devices for Asphalt Pavement Recycling Operations

Agency: Kossuth County and Iowa Department of Transportation, Highway Division

Principal Investigator: R. Schiek

Research Period: April 11, 1977, to December 31, 1982

Research Funding: \$50,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To seek acceptable solutions to the air pollution problem created in the asphalt recycling process using modified conventional equipment.

Progress: The project was constructed in 1977 and all aspects were considered to be very successful. Recycled asphalt proved to be good quality material at a savings of approximately 30 cents per ton over virgin material. Through modifications of equipment, all D.E.Q. requirements for air pollution were easily met and the project gained nationwide and worldwide recognition. A final report is to be submitted by December 31, 1982.

Reports: Progress Report, December 1977

Implementation: In the interest of conserving energy and material, the elimination of the problem of air pollution in the asphalt recycling process is a very desirable goal. The "drum in a drum" asphalt plant modification will prevent pollution while allowing normal production utilizing recycled materials. The plant modification is commercially available and will promote recycling, and in turn, conservation of natural resources.

Project Number: HR-192

Project Title: An Evaluation of Dense Bridge Floor Concrete

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R. A. Britson

Research Period: May, 1977, to December 31, 1982

Research Funding: \$3,340

Funding Source: 100 percent State--Primary funds

Objective: To determine the feasibility of mixing, placing and finishing dense portland cement concrete using a super water reducing admixture in a bridge floor. To determine the economics, longevity and maintenance performance of dense portland cement concrete.

Progress: The project is located in the Town of Ackley on U.S. 20 in Hardin County. The construction involved the redecking of a multiple span overhead crossing over a railroad. It was proposed that approximately 25 percent of the bridge deck be placed full depth using a concrete containing a super water reducing admixture. A portion of a full depth bridge deck using concrete with a high range water reducer was placed in August 1977. Problems were encountered in pumping the concrete and in controlling slump and air content. Cores from the deck yielded good air contents for both the Standard D-57 concrete and the high range water reducer (HRWR) concrete. The calculated one-year strength for the D-57 concrete was 6650 psi and 8500 psi for the HRWR concrete. The chloride content was slightly higher in the D-57 concrete. The cores revealed good consolidation of both concretes, even though the bottom surface of the HRWR exhibited an open honeycomb appearance.

Reports: Construction Report, December 1977.

Implementation: There is still a need for an improved concrete to retard the intrusion of chlorides. This project will determine if the admixture is a solution to the problem of corrosion of steel in bridge decks.

Project Number: HR-198

Project Title: Preliminary Archaeological Investigation Along Proposed Highway Right-of-Way

Agency: State Archaeologist (University of Iowa)

Principal Investigator: D. Anderson, State Archaeologist

Research Period: July 1, 1977, to June 30, 1982

Research Funding: \$75,000 (Revolving Fund)

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To determine well in advance of highway construction if proposed planning corridors contain known or probable sites of archaeological value; to locate such sites and describe their limits as accurately as possible without resorting to excavation or other detailed examination.

Progress: The Iowa Department of Transportation has an ongoing contract with the State Archaeologist to perform the needed preliminary investigations and prepare the necessary reports. Secondary road construction sites with archaeological value are being examined in advance of construction. Under a new Iowa DOT policy, a revolving fund has been established within the Secondary Road Research Fund to initially pay for the services of a survey contractor. Billings are then made to the counties and cities for their proportionate share of costs incurred. Additional funds were allocated to the revolving fund due to an unanticipated heavy load of Phase 2 testing activity. High potential sites, located through Phase 1 surface survey techniques, required additional subsurface examination in order to establish significance.

Reports: Annual reports are completed, giving a county-by-county summary of archaeological survey activities.

Implementation: The project will be beneficial because counties will know what type of projects should be reviewed and the reviews can be conducted in a more timely manner.

Project Number: HR-199

Project Title: Upgrading Asphalt Surface Friction by Aggregate Sprinkle Treatments

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R.A. Shelquist

Research Period: June 1, 1978, to December 31, 1983

Research Funding: \$42,500

Funding Source: 100 percent State--Primary funds

Objective: To determine the feasibility and cost effectiveness of using standard asphalt mixtures of local aggregates for 1" and 1½" thick surface courses, followed by a surface sprinkle treatment of pre-coated hard, durable chips to produce a long lasting non-skid pavement surface.

Progress: This experimental type of resurfacing was applied on old U.S. 30 between Interstate 35 and the City of Nevada in 1978. Appearance is very good, with the exception of some corregation which occurred during application. Texture depth tests by the silly putty method and friction tests of the sections are being conducted on a periodic basis.

Reports: Progress Report, October 1979

Implementation: This project will be utilized in the evaluation of paving materials and texturing. It will also assist in determining the effectiveness of sprinkle treatment in providing durable friction properties.

Project Number: HR-203

Project Title: Transverse Joint Sealing with Various Sealants

Agency: Dallas County and the Iowa Department of Transportation, Highway Division

Principal Investigator: G. Hardy, V.J. Marks

Research Period: July 25, 1978, to December 31, 1983

Research Funding: \$51,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To evaluate the performance of pcc pavement contraction joints utilizing a variety of sealants and joint preparations and to identify an effective joint sealant system.

Progress: These experimental pavement joints were incorporated into a Secondary Road paving project in Dallas County during the 1978 construction season. Joint sealing procedures, materials and specifications were determined prior to construction. Six different sealant materials were used with three methods of joint cleaning. Other variables were introduced and some cost comparisons were made. Core samples for joint sealant analysis were taken in 1979 and 1980. Visual observations are being made annually. Evaluation of the various joint sealing procedures is continuing. Attempts to find an effective joint sealant system will continue.

Reports: Progress Report, July 1979

Implementation: Deterioration of joints and joint-related distress of pcc pavements has continued to be a major maintenance problem. This project will identify the effective methods of joint preparation and sealing.

Project Number: HR-205

Project Title: Effects of Special Aggregate on Bridge Deck Overlay Frictional Properties

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: V.J. Marks

Research Period: December 14, 1978, to December 31, 1985

Research Funding: \$3,150

Funding Source: 100 percent State--Primary funds

Objective: To evaluate the benefit of incorporating a hard, durable aggregate in a dense pc concrete bridge deck overlay to provide frictional property longevity.

Progress: Special coarse aggregate was used in two bridge deck overlay projects on Interstate 35 near Ankeny. Resurfacing of the bridge decks was completed in the summer of 1979. The use of special aggregates resulted in a more consistent mix with improved workability and greater ease of finishing and texturing. Friction testing is being conducted on the bridges on a regular basis.

Reports: None

Implementation: Hard, durable aggregates will help to provide improved frictional property longevity in bridge deck overlays.

Project Number: HR-206

Project Title: Cement Produced from Fly Ash and Lime

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: W. Rippie

Research Period: April 1, 1979, to October 31, 1982

Research Funding: \$2,510

Funding Source: 100 percent State funds--50 percent Primary and 50 percent Farm-to-Market

Objective: To determine if a fly ash-lime cement with desirable characteristics can be produced, and to determine the combination of ingredients necessary to attain this end.

Progress: Fine crushed limestone and fly ash were obtained, pulverized and blended. The mixture was submitted to the Coal Research Laboratory of the University of West Virginia for fusion in an induction furnace. Some concrete strength specimens have been made and tested using the fused and crushed material as the cementitious ingredient.

Reports: None

Implementation: In view of continued shortages of portland cement, utilization of fly ash, a waste product, will conserve energy and increase the cement supply for construction projects.

Project Number: HR-208A

Project Title: Evaluation of Control Structures for Stabilizing Degrading Stream Channels in Western Iowa

Agency: Iowa State University

Principal Investigators: R.A. Lohnes, F.W. Klaiber, and M.D. Dougal

Research Period: December 1, 1980, to November 30, 1983

Research Funding: \$137,725

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To design and install several types of grade stabilization control structures in at least two streams in western Iowa, instrument them, and scientifically document their effectiveness.

Progress: Six demonstration sites, three in Shelby County and three in Pottawattamie County, have been selected for initial field installation and operational studies. Preliminary designs for the control structures have been completed. The designs include three vertical sheetpile structures, two soil-cement structures, and one pre-cast concrete structure. Hydraulic and structural analysis of the proposed structures are in progress.

Reports: Progress Reports, May 1981 and December 1981

Implementation: Bridge structures are expensive to construct and maintain. If more economical methods of grade stabilization can be developed, it will result in shorter bridges and save millions of dollars for counties in western Iowa.

Project Number: HR-209

Project Title: Pavement Surface on Macadam Base

Agency: Adair County and the Iowa Department of Transportation, Highway Division

Principal Investigator: D.J. Lynam

Research Period: June 26, 1979, to December 31, 1983

Research Funding: \$100,347

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To determine the feasibility, economics and performance of placing pc concrete on macadam base while developing design criteria by varying the thickness of the pc concrete and to determine if the macadam base is effective in reducing D-cracking deterioration of concrete produced with limestone having poor durability characteristics.

Progress: Construction was completed on approximately two miles of Adair County Road G-61 in 1979. Seven different roadway typical sections were utilized. A variation in shoulder construction with improved drainage was incorporated into one section. One mile adjacent to the experimental construction was included in the evaluation of the research. Minor construction problems were initially encountered in placing the thin section of pcc on the stone base. Road Rater evaluations of the pavement have been made. Some small areas of distress are visible, but the overall appearance of the pavement is good.

Reports: Construction Report, 1980

Implementation: This study will result in the ability to construct a pavement with improved performance in regard to D-cracking and subgrade failure at a lower cost.

Project Number: HR-210

Project Title: The Effect of Deer Reflectors on Deer-Vehicle Accidents

Agency: Iowa Conservation Commission, Iowa Department of Transportation, Highway Division

Principal Investigators: L. Gladfelter, H. Dolling

Research Period: June 15, 1979, to September 30, 1983.

Research Funding: \$30,072

Funding Source: 100 percent State--Primary funds

Objective: To evaluate the "Swareflex" and Bosch reflector system in reducing deer-vehicle accidents, to determine a cost benefit ratio for the system and to identify deer crossing areas throughout the state for possible implementation of the system.

Progress: Traffic counting equipment was installed at five designated sites. Deer-vehicle accident records were maintained for one year prior to the installation of the reflectors. The study areas selected are distributed around the state to include different driving conditions, traffic volumes and deer densities. Red Swareflex reflectors were mounted at four sites. Silver reflectors purchased from the Robert Bosch Corporation were installed at one site for comparison purposes. A number of Swareflex reflectors had to be replaced due to a design problem. Additional data will be needed to determine any meaningful results from the installation of the deer reflectors. However, results from the first and second years of data indicate a possible decrease in deer-vehicle accidents.

Reports: Progress reports, June 1980, June 1981 and June 1982

Implementation: An effective deer reflector will reduce deer-vehicle accidents and thereby result in savings to the motorist.

Project Number: HR-211

Project Title: Performance of Randomly-Oriented Fiber-Reinforced Roadway Soils (A Laboratory and Field Investigation)

Agency: Iowa State University

Principal Investigator: J.M. Hoover

Research Period: July 1, 1979, to October 31, 1982

Research Funding: \$143,207

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To conduct a laboratory and field investigation into the potential for improving soil-aggregate surface and roadway subgrade materials, and local base course materials by strengthening these materials through fibrous reinforcement.

Progress: Field demonstration sections using a variety of fibers were constructed in Linn and Story counties during the summer of 1980. On the Linn County project, three different types and three different percentages of fibers were used. The Story County project was constructed on an existing gravel road. Some difficulty was experienced in mixing the fibers into the roadbed due to equipment failure.

Reports: Five Progress Reports through January 1982

Implementation: Due to economic restraints, new and cost-effective methods are needed for the improvement of subgrade base course construction. This project will aid in the development of new and improved design procedures.

Project Number: HR-213

Project Title: Improved Asphalt Surfaces and Asphalt Resurfacing Performance Through Crack Maintenance

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R.R. Samuelson

Research Period: November 12, 1979, to March 1, 1985

Research Funding: \$13,500

Funding Source: 100 percent State--Primary funds

Objective: To provide better asphalt roadways through evaluation of various combinations of cleaning and crack preparation, and to identify the most effective maintenance procedure and the most effective preparation in providing improved resurfacing performance.

Progress: A Vanguard 2000 PSI waterblaster was purchased from a Des Moines distributor. This high-pressure washer was used extensively for joint and crack maintenance on various primary and interstate highways.

Reports: None

Implementation: Better methods of joint and crack maintenance will result in improved riding qualities and may permit the use of thinner overlays on asphalt roadways.

Project Number: HR-214

Project Title: Feasibility Study of Strengthening Existing Single Span Steel Beam Concrete Deck Bridges

Agency: Iowa State University

Principal Investigator: F.W. Klaiber

Research Period: March 12, 1980, to May 31, 1981

Research Funding: \$58,895

Funding Source: 100 percent State funds--50 percent Primary, 50 percent Farm-to-Market

Objective: The development of economical techniques to increase both the live load and dead load carrying capacity of existing single span steel beam concrete deck bridges.

Progress: The final report has been received. A one-half scale model of a 50' x 30' I-beam bridge was constructed for laboratory testing. Strain gauges were attached to the concrete deck to measure concrete strains. Post tensioning rods were attached to individual beams with bolted-on brackets designed for that purpose. The bridge was loaded and strain measurements were made. It was determined that existing composite concrete deck, steel I-beam bridges can be strengthened by post tensioning.

Reports: Final Report, June 1981

Implementation: There are a number of old single span steel beam concrete bridges that are not in compliance with present bridge standards. This research determined the feasibility of strengthening these bridges to avoid posting load limits. A field test has been approved at two locations.

Project Number: HR-215

Project Title: Improvement of Longitudinal Joints in Asphalt Pavement

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R.A. Shelquist

Research Period: March 5, 1980, to January 31, 1987

Research Funding: \$10,700

Funding Source: 100 percent State--Primary funds

Objective: To identify construction procedures that will provide an improved longitudinal centerline joint.

Progress: Asphalt widening and resurfacing were completed on Iowa 44 in Guthrie and Dallas counties in August 1980. Core samples to determine densities were taken that fall. Visual observations are made annually.

Reports: Construction Report, February 1981

Implementation: Improved methods for construction of longitudinal joints will result in increased life of asphalt resurfacing by reducing joint deterioration.

Project Number: HR-216

Project Title: Emulsion Treated Macadam Base

Agency: Dubuque County, Iowa Department of Transportation, Highway Division

Principal Investigator: C.L. Baule

Research Period: April 28, 1980, to January 15, 1985

Research Funding: \$156,289

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To identify and construct a cost-effective asphalt emulsion bound macadam section and to evaluate the performance of an asphalt bound macadam as compared to unbound macadam.

Progress: Construction of the macadam sections was completed in September 1980. The most serious problem encountered in the project was the inability to obtain complete coating of the emulsion treated materials. More favorable weather conditions and modified construction procedures helped alleviate this problem. Riding quality and overall appearance of this experimental pavement is satisfactory. Evaluation will continue for a five-year period.

Reports: Construction Report, January 1981

Implementation: Macadam base projects in the past have provided excellent drainage characteristics. The use of asphalt emulsion binder and engineering fabrics will result in energy savings and improved stability, while still providing a relatively low-cost roadway base.

Project Number: HR-217

Project Title: Reducing the Adverse Effect of Transverse Cracking

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: V.J. Marks

Research Period: March 7, 1980, to January 31, 1984

Research Funding: \$43,000

Funding Source: 100 percent State--Primary funds

Objective: To identify a method of reducing the adverse effect of transverse cracking and improving the performance of asphalt pavement.

Progress: The research was incorporated into a Jones County primary project on Iowa 64, which was completed in September 1980. Some of the variations from standard construction practices used in this project included the following: 1. Use of an asphalt that is partially blown and less susceptible to temperature variations; 2. Variation in mix designs; 3. The sawing and sealing of transverse joints. No particular problems were experienced in this research. Density and gradation requirements were satisfactorily met. There is very little cracking in the pavement produced from the asphalt cement exhibiting low temperature susceptibility. The pavement produced from the highly temperature susceptible asphalt cement exhibits severe cracking. The sealant has failed in the sawed joints.

Reports: Construction Report, February 1981

Implementation: With the prevention of transverse cracking and subsequent crack deterioration, asphalt surfaced roads will last longer and require less maintenance and less frequent resurfacing.

Project Number: HR-219

Project Title: Settlement at Culverts and Bridges

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: W.E. Buss

Research Period: May 1980, to January 31, 1984

Research Funding: \$11,200

Funding Source: 100 percent State--Primary funds

Objective: To identify cost-effective construction methods that may prevent settlement at culverts and bridges.

Progress: This research was incorporated into a grade, culvert, pavement widening and resurfacing project on Iowa 44 in Dallas County. Various methods of backfilling and bedding for bridges and culverts were completed by the contractor by extra work order. K-Krete, sand and Class A material with moisture control were used on the bridge approaches. K-Krete and Class A, B and C road stone were used in various combinations in the culvert replacement and backfill. No significant settlement has been noted to date.

Reports: Construction Report, December 1981

Implementation: The reduction in settlement will result in less maintenance and will provide the best method of backfill at a reasonable cost.

Project Number: HR-220

Project Title: Protection of Structural Concrete Substructures

Agency: Iowa Department of Transportation, Highway Division

Principal Investigators: J. Risch, J. Whiting

Research Period: May 1980, to July 15, 1985

Research Funding: \$8,000

Funding Source: 100 percent State--Primary funds

Objective: To field test the long-term effectiveness of several available products or procedures for their ability to protect concrete surfaces against the intrusion of chloride ions.

Progress: A substantial number of cores were drilled from bridge pier columns on I-235 in Des Moines and I-380 in Cedar Rapids to determine the chloride contamination. A number of commercially available waterproofing products were used, with varying application rates and surface preparation methods, to determine their potential for preventing chloride intrusion. Cores will be taken annually to monitor the chloride content of the pier column concrete.

Reports: Construction Report, February 1981

Implementation: A protective system will prevent the intrusion of chlorides into structural concrete and will help to prevent the need for repairs which are both difficult and expensive.

Project Number: HR-221

Project Title: Construction and Maintenance Practices to Minimize the Potential Liability of Counties for Roads in Rural Subdivisions

Agency: Iowa State University

Principal Investigator: R.L. Carstens

Research Period: July 1, 1980, to August 31, 1981

Research Funding: \$40,465

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To identify specific street-related problems that have given rise to claims against municipalities, and to determine corrective actions that have been shown to be effective as countermeasures in avoiding or mitigating situations that typically lead to street-related tort claims. A survey asking information on highway-related tort claims was mailed to 259 Iowa cities. Of these, 63 percent were completed and returned. Over one-third of the claims reported were based on alleged street defects. Another 34 percent of the claims contained allegations of damages due to backup of sanitary sewers or defects in sidewalks. Several recommendations were made concerning the review of subdivision plats and the conduct of maintenance in cities and rural subdivisions.

Reports: Final Report, August 1981

Implementation: Proper planning, design, construction and maintenance will avoid mitigating situations and reduce street-related tort claims.

Project Number: HR-222

Project Title: Retardation of Reflection Cracking Using Stabilizing Additive 5990

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: R.A. Shelquist

Research Period: July 1, 1980, to June 30, 1986

Research Funding: \$17,500

Funding Source: 100 percent State--Primary funds

Objective: To evaluate the use of Stabilizing Additive 5990 (a mixed polymer in granular form) as a method of reducing cracking in asphaltic concrete overlays.

Progress: A crack survey was made of the existing portland cement concrete prior to construction. The asphaltic concrete resurfacing has been laid. Periodic crack surveys have been made.

Reports: None

Implementation: Any product or method that will prevent reflection cracking will save maintenance funds spent for crack sealing.

Project Number: HR-224

Project Title: Restoration of Frictional Characteristics on Older PCC Pavement

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: V.J. Marks

Research Period: July 1, 1980, to December 31, 1983

Research Funding: \$8,000

Funding Source: 100 percent State--Primary funds

Objective: To identify a cost-effective method of restoring the friction characteristics on older pcc pavement.

Progress: Three experimental applications of systems to improve the texture of pcc have been applied to older pavement. Transverse grooving was cut into a northbound lane of I-29 at the north edge of Council Bluffs adjacent to a longitudinal grooving safety enhancement project in July 1980. A very thin lift (about 1/2 inch) of hot sand asphalt was placed on I-80/I-35 at the north edge of Des Moines in September 1980. A small patch (4' x 4') of latex modified concrete surface dressing was placed on northbound I-35 just south of Ames to determine its durability. Friction testing of the grooving and hot sand asphalt is being conducted annually.

Reports: Construction Report, April 1981

Implementation: A cost-effective method of restoration of pcc friction properties will yield substantial savings.

Project Number: HR-225

Project Title: Characterization of Fly Ash for Use in Concrete

Agency: Iowa State University

Principal Investigator: Turgut Demirel

Research Period: August 1, 1980, to January 31, 1982

Research Funding: \$89,660

Funding Source: 100 percent State funds--50% Primary, 50% Farm-to-Market

Objective: To determine the components or combinations of components in fly ash responsible for good or poor performance of concrete and to quantify fly ash variability.

Progress: Thirty-five fly ash samples were collected from seven power plants. Elemental analyses of all fly ash samples have been performed using x-ray fluorescence. Concrete mixes have been prepared and subjected to freeze-thaw testing and x-ray diffraction analysis.

Reports: Interim Report, December 31, 1981

Implementation: The research will establish criteria for predicting the suitability of a given fly ash for use in highways in Iowa.

Project Number: HR-226

Project Title: Iowa Research with Chem-Crete Bitumen

Agency: Story County and Iowa Department of Transportation, Highway Division

Principal Investigators: D. Jespersen, K. Jones

Research Period: August 1980, to October 31, 1984

Research Funding: \$44,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To determine if Chem-Crete bitumen will provide significantly improved performance of the mix designs used, and to determine if a satisfactory asphalt concrete base can be made using a poorly graded sand.

Progress: Test sections of Chem-Crete resurfacing and standard asphalt resurfacing were constructed in September 1980 on Story County Roads E-57 and North Dakota Street Extension (Ames). Soon after construction, cracks in the Chem-Crete test sections appeared. The Chem-Crete Corporation is working with Story County to determine how to correct the problem. Evaluation will continue for a four-year period.

Reports: Construction Report, November 1981

Implementation: Products which result in improved characteristics of low quality aggregate will allow the use of locally available aggregate, thereby conserving resources and reducing cost.

Project Number: HR-227

Project Title: Piling Stresses in Bridges with Integral Abutments

Agency: Iowa State University

Principal Investigators: Lowell F. Greimann and Amde M. Wolde-Tinsae

Research Period: December 1, 1980, to August 31, 1982

Research Funding: \$34,855

Funding Source: 100 percent State funds--50 percent Primary, 50 percent Farm-to-Market

Objective: To determine the maximum length to which bridges with integral abutments can be safely designed.

Progress: A questionnaire was sent to the 50 states, Puerto Rico, and the FHWA Region 15 Construction Office. The questions concerned limitations in bridge length, type and skew. The research for the original study was completed in February 1982, showing the 265-foot limitation to be very conservative. The study was extended to include skewed bridges with no additional funding.

Reports: Final Report, February 1982

Implementation: Currently, bridges with integral abutments are limited to 265 feet in Iowa. If the maximum safe length of these bridges is determined to be longer, savings of highway dollars would be realized.

Project Number: HR-228

Project Title: Engineering Study - Automating Iowa's Speed Monitoring Program

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: Shyamal Basu

Research Period: March 1, 1981, to October 30, 1982

Research Funding: \$48,540

Funding Source: 100 percent State funds--78 percent Primary, 22 percent Farm-to-Market

Objective: To develop and make operational a system with flexible capabilities of collecting accurate speed data on all road systems in Iowa.

Progress: Inductance loops have been installed in the pavement at 33 sites. Six print/punch automatic speed monitoring devices have been obtained and checked for accuracy.

Reports: Progress Report, November 1981

Implementation: The use of this automatic equipment will result in reduced cost of data collection while improving the quality of that data.

Project Number: HR-229

Project Title: Alternate Flexible Overlays

Agency: Osceola County and Iowa Department of Transportation, Highway Division

Principal Investigators: P. Schwarting, C. Leonard

Research Period: March 1981, to October 1987

Research Funding: \$130,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To construct and evaluate several bituminous concrete base overlays which have the potential to reduce future maintenance and construction costs.

Progress: Eight different test sections of cold-laid bituminous overlays were constructed in September 1981 on Osceola County Roads A-34 and A-46. Aggregate for four of the test sections consisted of salvaged asphalt pavement and new aggregate combined. The other four test sections contained only new aggregate. Four types of asphalt binder were mixed with each aggregate to develop the eight test sections. A seal coat has been placed on all test sections to provide a wearing surface. Evaluation will continue for six years.

Reports: A construction report will be submitted in February 1983

Implementation: Identification of a surface which is less prone to transverse cracking will result in a substantial savings due to increased life and reduced maintenance of asphalt concrete pavements.

Project Number: HR-230

Project Title: An Investigation of Signing Needs at Uncontrolled Local Road Intersections

Agency: Iowa State University

Principal Investigators: K.A. Brewer, W.F. Woodman

Research Period: April 1, 1981, to March 31, 1982

Research Funding: \$56,305

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To investigate the variety of legend and symbol face combinations of sign designs to determine whether there are any other combinations which may better communicate with drivers approaching local uncontrolled intersections. To identify the alternative courses of action available to any county encountering such a problem intersection on their local road system.

Progress: An Apple II computer was programmed to display a view of selected local road intersection approaches from "over the driver's shoulder." An array of sign displays was shown between each intersection type. A booth at the 1981 Iowa State Fair was used to obtain participation from rural residents in the driver communication tests. Four hundred and five responses were recorded and used for statistical analysis. The report contains findings from the surveys that were conducted as well as recommendations for dealing with problem local uncontrolled intersections.

Reports: Final Report, April 1982

Implementation: The project will identify courses of action counties may consider for a problem intersection on their local road system to improve safety, thus reducing accidents.

Project Number: HR-231

Project Title: Special Surface Preparation Prior to Bituminous Overlay

Agency: Cerro Gordo County and Iowa Department of Transportation, Highway Division

Principal Investigator: W. Davison

Research Period: May 1981, to April 1986

Research Funding: \$45,340

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To identify an effective crack sealing procedure which will extend the service life of a roadway and lower maintenance costs.

Progress: Four crack sealing methods were done in May 1982 on Cerro Gordo County Road S-25. The crack filling materials were standard emulsion sealer, rubberized asphalt sealer, pressure-injected fly ash-cement slurry and pressure-injected limestone-emulsion slurry. Three test sections were formed by repeating the four crack sealing procedures along the length of the project. Overlays for the three sections were 2" of Type "B" asphalt cement concrete, 1½" of Type "B" asphalt cement concrete, and a limestone-emulsion slurry seal. Crack sealing with the limestone-emulsion slurry was discontinued after several unsuccessful attempts at mixing the material. Evaluation will continue for a five-year period.

Reports: None

Implementation: A procedure of properly sealing thermal cracks prior to a bituminous overlay should extend the life of the overlay, reduce maintenance costs, and improve the ride quality of the roadway.

Project Number: HR-232

Project Title: Reducing the Problem of Transverse Cracking

Agency: Iowa Department of Transportation, Highway Division

Principal Investigators: R. Merritt and V. Marks

Research Period: May 1, 1981, to March 1, 1985

Research Funding: \$4,105

Funding Source: 100 percent State--Primary funds

Objective: To identify a method of reducing the adverse effect of transverse cracking and improving the performance of asphalt pavement.

Progress: Engineering fabric was used in full depth asphalt construction on a Jones County project. For two experimental sections, the fabric was placed on grade beneath the asphalt treated base. The fabric was placed between lifts of the asphalt treated base for two other sections. No cracking has been noted to date.

Reports: None

Implementation: The prevention of transverse cracking and subsequent deterioration will increase the life of asphalt surfaced roads and require less maintenance and less frequent resurfacing.

Project Number: HR-233

Project Title: Field Demonstration and Evaluation of Foamed Asphalt

Agency: Shelby County, Iowa State University and the Iowa Department of Transportation, Highway Division

Principal Investigators: E. Schornhorst, D.Y. Lee

Research Period: May 1, 1981, to March 1, 1986

Research Funding: \$138,405

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To evaluate the performance of foamed asphalt as a stabilizing agent using existing soils and granular surfacing material; to correlate field strength characteristics and performances of foamed mixes with laboratory strength characteristics and performances; and to develop specifications and evaluate construction procedures and inspection tests.

Progress: The planned project is a three-mile section of Shelby County Road M-56. Eight test sections comprised of a base six inches deep, using existing soil and granular surfacing material with AC-5 foamed asphalt cement as the binder material will be constructed. The eight test sections will include two levels of moisture content and four levels of surface treatments: no surface treatments, fog seal, single chip seal and double chip seal.

Reports: None

Implementation: Foamed asphalt offers potential for energy conservation and the utilization of marginal locally available aggregates.

Project Number: HR-234

Project Title: Compilation of Iowa Highway Laws

Agency: Iowa Department of Transportation, Office of General Counsel

Principal Investigator: R. Goodwin

Research Period: May 15, 1981, to September 1, 1981

Research Funding: \$5,000

Funding Source: 100 percent State funds--40 percent Primary, 60 percent Farm-to-Market

Objective: To provide a current annotated Iowa Highway, Road and Street Law publication.

Progress: Two law clerks were retained on a temporary basis to search out the laws and pertinent court cases and draft the publication for the Director of the Iowa DOT General Counsel Division.

Reports: None

Implementation: With this handy reference to ascertain applicable laws and decisions, highway engineers will avoid oversights that may result in costly legal claims.

Project Number: HR-235

Project Title: Warrants for Rumble Strips on Rural Highways

Agency: Iowa State University

Principal Investigator: R.L. Carstens

Research Period: June 16, 1981, to June 30, 1982

Research Funding: \$49,850

Funding Source: 100 percent State funds--25 percent Primary, 75 percent Farm-to-Market

Objective: To improve safety on rural highways by recommending guidelines or warrants for the use of rumble strips; to reassess the conclusions regarding rumble strip installations that were studied in the research project HR-184, "Determination of Rumble Strip Effectiveness."

Progress: An inventory of rumble strips in use on highways in Iowa was undertaken. Data was collected for 147 comparative locations and 109 locations, with before and after installation records. Accident data and physical characteristics of the locations were analyzed to determine what factors distinguished locations that experienced a reduction in accidents following rumble strip installation from those where no such reduction had occurred. The report suggests that in many instances, the installation of rumble strips will have no effect on the occurrence of accidents. However, analysis of before and after samples indicated that the accident rate could be expected to improve following installation of rumble strips only if it were above 2.5 accidents per million entering vehicles (MEV) at secondary locations and above 2.0 accidents per MEV at primary locations.

Reports: Final Report, June 1982

Implementation: A reduction of accidents would occur if rumble strips are installed where they are warranted but do not exist. Cost savings will arise if rumble strips are not installed where they are not warranted.

Project Number: HR-236

Project Title: Pottawattamie County Evaluation of Control Structures for Stabilizing Degrading Stream Channels

Agency: Pottawattamie County, Iowa State University and Iowa Department of Transportation, Highway Division

Principal Investigators: C.E. Hales, R.A. Lohnes, F.W. Klaiber, T. Austin

Research Period: July 10, 1981, to June 1, 1986

Research Funding: \$88,143

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To design and construct three types of grade stabilization control structures for Keg Creek, instrument them, and scientifically document their effectiveness.

Progress: Preliminary designs for the control structures have been completed. The designs include a vertical sheet-pile structure, a soil-cement structure, and a pre-cast concrete structure. Hydraulic and structural analysis of the proposed structures are in progress.

Reports: None

Implementation: Bridge structures are expensive to construct and maintain. If more economical methods of grade stabilization can be developed, it will result in shorter bridges and savings of millions of dollars for counties in western Iowa.

Project Number: HR-237

Project Title: Shelby County Evaluation of Control Structures for Stabilizing Degrading Stream Channels

Agency: Shelby County, Iowa State University and the Iowa Department of Transportation, Highway Division

Principal Investigators: E. Schornhorst, R.A. Lohnes, F.W. Klaiber, T. Austin

Research Period: July 10, 1981, to June 1, 1986

Research Funding: \$87,065

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To design and construct three types of grade stabilization control structures for two creeks in Shelby County, instrument them, and scientifically document their effectiveness.

Progress: Preliminary designs for the control structures have been completed. The designs include two vertical sheet-pile structures and a soil-cement structure. Hydraulic and structural analysis of the proposed structures are in progress.

Reports: None

Implementation: Bridge structures are expensive to construct and maintain. If more economical methods of grade stabilization can be developed, it will result in shorter bridges and savings of millions of dollars for counties in western Iowa.

Project Number: HR-238

Project Title: Strengthening Existing Single Span Steel Beam Concrete Deck Bridges

Agency: Iowa State University

Principal Investigator: F.W. Klaiber

Research Period: July 1, 1981, to September 30, 1984

Research Funding: \$79,228

Funding Source: 100 percent State funds--50 percent Primary, 50 percent Farm-to-Market

Objective: To design and install post-tensioning strengthening on two single span steel beam concrete deck bridges, instrument them, and document their performance over a period of two years following post-tensioning.

Progress: A bridge on a Farm-to-Market road in Dickinson County and a bridge on Iowa 144 in Greene have been selected for post-tensioning. Brackets have been fabricated to hold the post-tensioning bars in place.

Reports: Progress Report, December 31, 1981

Implementation: Bridges that do not meet current standards for live load carrying capacity could have the capacity restored, causing posted limits to be raised or removed. In some cases, bridges which have been restricted to one-lane traffic could have the restriction removed.

Project Number: HR-239

Project Title: Engineering Study to Evaluate Secondary Bridges with Respect to Current Truck Length and Weight Laws

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: J.P. Harkin

Research Period: August 25, 1981, to October 31, 1982

Research Funding: \$80,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To reanalyze the secondary bridge standard designs according to current length and weight laws of the state of Iowa.

Progress: An agreement was authorized with Wallace, Holland, Kastler and Schmitz Consulting Engineers to conduct the major portion of the work. Over 500 standard bridge designs are being rated. Two final reports will be submitted by October 1982. The first report will contain the rating for each standard bridge and the second will contain the calculations used to arrive at those ratings.

Reports: None

Implementation: The study will: 1. Avoid duplication of bridge evaluations and result in a cost savings for the counties; 2. Facilitate the bridge posting on the secondary road system; and 3. Aid in the evaluation of damaged or deteriorated bridges on the secondary road system.

Project Number: HR-240

Project Title: Systems to Control Corrosion in Concrete

Agency: Iowa Department of Transportation, Highway Division

Principal Investigators: J.E. Whiting, V.J. Marks

Research Period: April 1, 1982, to March 15, 1985

Research Funding: \$88,000

Funding Source: 100 percent State--Primary funds

Objective: To field test protective systems for substructures and identify a system or systems that will halt corrosive activity.

Progress: The site selected for this research was Interstate 235 in Des Moines from 2nd Avenue to 9th Street. The research is to be incorporated into a pier rehabilitation project. The protective systems to be considered are cathodic protection, moisture starvation and oxygen starvation. Delays have been encountered due to problems of executing a contract with the cathodic specialty contractor.

Reports: None

Implementation: Many of the older bridge structures are exhibiting substantial deterioration. A system to halt corrosive activity would save millions of dollars in pier column rehabilitation.

Project Number: HR-241

Project Title: Development of Electronic Distance Measuring Instrument (EDMI) Calibration Baseline

Agency: Iowa State University

Principal Investigator: K. Jeyapalan

Research Period: March 8, 1982, to March 31, 1984

Research Funding: \$8,500

Funding Source: 100 percent State--47 percent Primary, 53 percent Farm-to-Market funds

Objective: To develop a mathematical model to determine the scale and constant of the EDM; to develop a computer program for calculation of the EDM scale and constant; and to evaluate the stability of the baseline.

Progress: The baseline was established on an Iowa State University farm just southwest of Ames.

Reports: None

Implementation: Use of the baseline and EDM calibration procedure will assure survey accuracy and prevent loss due to legal action.

Project Number: HR-243

Project Title: Production and Evaluation of Calcium Magnesium Acetate (CMA)

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: W. Rippie

Research Period: January 2, 1982, to April 30, 1982

Research Funding: \$3,445

Funding Source: 100 percent State--Primary funds

Objective: To evaluate the effectiveness of CMA as a deicer under actual use conditions and investigate the possibilities of producing CMA with a high magnesium acetate content and evaluate its properties.

Progress: About 10 tons of CMA deicer were produced in the Materials Laboratory for field use. Production was with a 6-cubic foot cement mixer and an older pug mill-type mixer. Two sections of highway near Ames were used in field trials.

Reports: None

Implementation: CMA as a deicing agent offers a potential savings by reducing corrosion of reinforcing steel in bridges.

Project Number: HR-244

Project Title: Detection of Concrete Delaminations by Infrared Thermography

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: B. Brown

Research Period: May 1, 1982, to December 1, 1982

Research Funding: \$9,700

Funding Source: 100 percent State--Primary funds

Objective: To assess the accuracy, dependability, and potential of the infrared thermographic technique of detecting bridge deck delaminations.

Progress: Fifteen bridges and five miles of thin bonded portland cement concrete have been surveyed by Donohue and Associates of Sheboygan, Wisconsin.

Reports: None

Implementation: Surveys of a great number of structures could be made in a given amount of time, thereby assisting in the timely programming of deck replacement or repair projects.

Project Number: HR-245

Project Title: Dynamic Deflections to Determine Roadway Support Ratings

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: V.J. Marks

Research Period: April 18, 1982, to March 31, 1983

Research Funding: \$1,000

Funding Source: 100 percent State--50 percent Primary, 50 percent Farm-to-Market funds

Objective: To determine if the Iowa DOT Road Rater can be used to determine support values for selected rigid pavements and layered systems.

Progress: The Iowa DOT Road Rater and the FHWA "Thumper" were used to determine the dynamic deflections on 25 different roadway sections. The sections included a variety of bases and pavements varying from a gravel surface on new grade to 10" of pcc and a 25" thick bituminous roadway. The Road Rater data has been summarized, but the Thumper data is not yet available.

Reports: None

Implementation: Improved testing and design procedures will yield the most cost effective pavement thicknesses that will provide the desired service life.

Project Number: HR-246

Project Title: Engineering Study - Reducing Sign Vandalism

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: K. Jones

Research Period: June 14, 1982, to February 1988

Research Funding: \$118,000

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To reduce the incidents and cost of sign vandalism.

Progress: A survey will be sent to the counties asking about accidents at locations where a sign had been vandalized. Educational material and sign identification material will be developed to be distributed to school children, the general public, and to the Iowa counties. Several counties will be selected to participate in the study by recording specific sign replacement information.

Reports: None

Implementation: The Federal Highway Administration estimates that at least 10 percent of all highway signs are vandalized each year. This costs the Iowa counties over \$1 million per year. One state conducted a public awareness campaign and achieved over a 50 percent reduction in signs being vandalized.

Project Number: HR-247

Project Title: Design Criteria for Low Water Crossings

Agency: Iowa State University

Principal Investigator: R.L. Rossmiller

Research Period: June 1, 1982, to May 31, 1984

Research Funding: \$88,260

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To develop a design procedure for low water stream crossings for use by the Iowa county engineers and to demonstrate the design procedure through field demonstration projects and training seminars.

Progress: The design procedure to be developed will include design criteria for the evaluation of the hydraulic, hydrologic, erosion control, structural, and location considerations for low water stream crossings in Iowa. Iowa counties currently experimenting with the crossings will be contacted and asked for their input.

Reports: None

Implementation: Iowa has nearly 8,000 deficient bridges on roads carrying less than 50 vehicles per day. Public demand is strong in favor of keeping these roads open. It is not economically feasible to replace the deficient bridges with new bridge structures. Low water stream crossings are a possible solution on many of very low volume roadways.

Project Number: HR-1027

Project Title: Secondary Road Research Coordinator

Agency: Iowa Department of Transportation, Highway Division

Principal Investigator: K. Jones

Research Period: March 5, 1980, to present

Research Funding: \$30,000 per year

Funding Source: 100 percent State--Farm-to-Market funds

Objective: To maintain research liaison with all county engineers and solicit new, innovative and progressive ideas; to actively promote secondary research for solutions to problems and ideas that will improve quality and reduce costs.

Progress: Kevin Jones, an Engineer-in-Training with the Iowa DOT, currently holds the position of "Secondary Road Research Coordinator" in the Office of Materials. Many of the county engineers have been visited to discuss problems being encountered by the secondary road departments and to discuss present research of interest. The Secondary Road Research Coordinator was instrumental in initiating three secondary research projects during the year. At present, there are 12 active research projects that involve experimental construction by counties. The coordinator assists these counties with special testing, evaluation, and writing of construction and final reports necessary to the research.

Reports: None

Implementation: There are many problems that are unique to the secondary road system in Iowa. These problems are usually common to several counties. Coordination between counties is necessary to understanding the problem and formulating solutions. Proper documentation and dissemination of reports will allow for timely technology transfer between the counties.

