Iowa Highway Research Board: 1949–1999

Joséph M. Isenberg

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Cover and title page photos
The Northwest 86th Street overpass on Interstate 35/80 in Urbandale, Iowa, shown here under construction in 1958, was the country’s first aluminum girder type highway bridge.
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Introduction

The year 1949 saw the Iowa General Assembly’s establishment of the Iowa Secondary Road Research Fund, which led to the creation of a supervisory board within what was then the Iowa State Highway Commission to oversee the expenditure of that fund. The purpose of the fund and the board was to research road construction topics likely to be beneficial to the working of Iowa’s secondary, or local, road system. The supervisory board—called the Iowa Highway Research Board (the “Board”)—was organized by the highway commission in December 1949 and first met in May 1950.

The creation of the fund and of the Iowa Highway Research Board marked the first organized effort in the United States to investigate local road construction problems and placed Iowa in the forefront of this field of engineering research. That Iowa should be a leader in such an effort is not surprising, given the early and sustained emphasis of the Iowa State Highway Commission on both research and the dissemination of information to county authorities.

Now, 50 years later, a retrospective is in order. To that end, the Iowa Highway Research Board commissioned the preparation of a commemorative history. This work is the result of that project. Throughout its existence, the Board has funded nearly 450 projects, several of national significance. Many new construction and maintenance techniques have been developed, some of which have evolved into standard practices in highway construction. Innovative new materials and equipment have been tested. Still other projects have considered a wide variety of subjects related to the efficient operation of the highway system. Highway safety, conservation, and law have all come under research scrutiny.

While it will not be possible, given the short space available, to consider all the projects financed by the Iowa Highway Research Board, it is well worthwhile to examine the Board’s principal projects and its resulting contributions to the field of highway research.
In 1949 the Fifty-Third Iowa General Assembly passed legislation creating the Secondary Road Research Fund to be administered by the Iowa State Highway Commission in consultation with the state’s county engineers. The fund was to be expended in pursuit of solutions to engineering problems in the construction and maintenance of Iowa’s secondary roads. To administer this fund and to guide the research contemplated as a consequence, the Iowa Highway Research Board was created within the highway commission.

By creating the Secondary Road Research Fund and the Iowa Highway Research Board, the state of Iowa placed itself in the forefront of highway research in the United States. Although the federal government had engaged in highway research since 1893, results had been decidedly mixed. State highway authorities, including the Iowa State Highway Commission, had also conducted ad hoc research in problems of interest. By 1949, however, no sustained program or central management for research had emerged in any of the states. Thus, the creation of the Secondary Road Research Fund and the Iowa Highway Research Board marked a new departure for engineering research. By its actions, Iowa was the first state to create a central agency to manage a highway research program. Other states soon followed this model.

For the next half century, the Iowa Highway Research Board would undertake a wide variety of research projects deemed useful to the practice of county, municipal, and state road builders. Several of those projects would receive national and international recognition for the novelty and utility of the results. What follows is the story of the Iowa Highway Research Board.

Iowa’s first “road schools”
It is scarcely surprising that Iowa placed a heavy emphasis on highway research. In the early 1900s the first chair of the Iowa State Highway Commission, Anson Marston, was an early advocate of engineering based on the scientific method. Marston represented a trend toward increasing professionalism in the engineering field whereby experimentally derived information increasingly replaced traditional rule-of-thumb approaches practiced early in the twentieth century without regard for empirically testable theories. As an example of this trend towards scientific information in engineering, some of Marston’s research at what was then Iowa State College focused on providing experimentally designed charts for road builders.

Anson Marston
Marston was professor and dean of engineering at Iowa State College. Together with Iowa State’s Charles F. Curtiss, he served on the Iowa State Highway Commission. In his work at both the college and the highway commission, Marston stressed the importance of research in engineering work. In the first year of the highway commission’s operation, Marston sponsored a road building course to familiarize county officials with construction techniques.

1905 highway commission road school
In this scene, participants are shown building a “modern” concrete culvert. Practical experience allowed local officials to gain valuable insights with materials and techniques then not often used in local road construction, such as concrete.
Given his background, it is not surprising that Marston wished to engage the Iowa State Highway Commission in a research program. Faced with a lack of trained personnel at the state and county levels and a lack of information about modern road construction, Marston sought to develop all aspects of road engineering. Thus, in the First Annual Report of the Iowa State Highway Commission, covering the 1904–1905 fiscal year, Marston and Charles F. Curtiss, in requesting additional funds for the highway commission, wrote:

We need funds to carry on extensive laboratory tests of the properties of Iowa road materials, and to build sections of experimental roads, to give actual working tests of material and methods of construction suited to Iowa’s needs.

We need funds to determine by actual tests the dimensions of concrete culverts and bridges necessary for strength to prepare full plans and specifications, and to employ an experienced concrete foreman to give actual demonstrations.

We need funds to complete the compilation of the road census and publish the results.

We need funds to extend our county investigations, and to complete our road maps.

Marston and Curtiss concluded their plea by requesting an increase in the highway commission’s budget to the minimum necessary to carry out the proposed program, which they estimated at $10,000 per annum. Without these additional funds, Marston and Curtiss argued, the “future work” of the highway commission would “be very seriously crippled.”

In addition to the lack of highway commission funds, road building in Iowa was then handicapped by a lack of trained individuals able to manage county and city road construction. Marston and Curtiss proposed to rectify this lack of expertise in two ways. They first undertook the creation of a training program for local road builders. The “road school” allowed for the training of a few individuals and also allowed the refinement of construction technique. Second, once construction technique was developed, Marston and Curtiss made this information available to local officials, together with such other research as the highway commission was able to undertake.

As part of these efforts, the Iowa State Highway Commission built two sections of experimental road in the 1904–1905 fiscal year. One road section, near Ames, was built of gravel and clay. The other section, near Anamosa, was built of stone. The highway commission also undertook to build several experimental concrete culverts to demonstrate construction technique.
The road school approach proved particularly helpful in disseminating information. Participants drawn from county and city road crews were able to work with concrete on road sections and with the experimental concrete culverts. As Marston hoped, the highway commission made the culvert plans available to local road builders on request.

Through a program of research, practical education, and dissemination of standardized information, Marston sought to improve the level of expertise among county road building officials. However, despite the need for a formal research and dissemination program aimed at improving local road building expertise, and despite the apparent utility of Marston’s early efforts to develop such a program, no formal research organization aimed at solving county engineering problems existed until the creation of the Iowa Highway Research Board in 1949. In the interim, the Iowa State Highway Commission focused on its own research needs. The highway commission conducted intermittent investigations and occasionally cooperated with national highway research efforts sponsored or organized by the national Highway Research Board of the National Academy of Sciences or by the U.S. Bureau of Public Roads.

**Early federal research**

Although not extensively developed, Iowa’s early efforts at highway research compared favorably to efforts undertaken by the federal government at approximately the same time. The agency principally responsible for federal transportation research was the U.S. Bureau of Public Roads. Bruce Seely, in one of the few works on the history of highway research, evaluated federal research efforts during the first few decades of the twentieth century in an article in the October 1984 issue of *Technology and Culture*. Seely described the early federal research program as by and large a failure. He argued that in the aftermath of World War I the federal engineering research program aggressively embraced scientific methodology. Unfortunately, the change from improving engineering practices to formulating general theories of engineering based on “fundamental” principles neither solved practical problems faced by engineers in local conditions nor provided basic information on materials.

The use of the scientific experimental method marked a fundamental change in operating procedure for the organization that would eventually become the U.S. Bureau of Public Roads. The Office of Road Investigation, formed in 1893, began by collecting statistical data on roads in the United States. It soon turned to physical testing of construction materials in a materials testing laboratory built in 1900. As a result, concrete samples cure prior to testing in the early 1920s.
result of this work, the office, renamed the Office of Public Roads, quickly gained a reputation for research expertise. By 1907 the Office of Public Roads was undertaking both road tests on public roads and experimental road construction at an experiment station in Arlington, Virginia. As a result of these efforts, by 1911 the Office of Public Roads was in a position to offer specifications both for road construction and testing methods. These recommendations were widely adopted by local road builders. The tests undertaken were overwhelmingly practical with no effort at synthesizing any theories of material behavior.

Unfortunately, these efforts led to little in the way of practical consequence. Although researchers were able to collect a great deal of information on the destruction of materials both in the real world and in the laboratory to which the bureau’s engineers increasingly retreated, they were unable to correlate that research with any improved road design methods. Similarly, while the bureau was capable of generating significant information about soil types and the physical properties of a wide range of soil samples, it was unable to form a general theory of soils, as had been hoped, or to determine which soil conditions were relevant to road construction practices.

In contrast, state officials working with the Bureau of Public Roads were able to develop practical information quickly by constructing experimental road sections using a variety of techniques and comparing durability among techniques. This trial-and-error method was derided by federal engineers as unsophisticated and incapable of producing “scientific,” verifiable results.

Highway research was impeded by the needs of the second world war. After the war, renewed interest in research led to the creation of a number of highway research organizations both in the United States and abroad. The first of these was the Iowa Highway Research Board.

Iowa’s farsighted legislature
In 1949 the Fifty-Third Iowa General Assembly undertook a general revision of the highway laws of the state. Special attention was given in this revision to the workings of the secondary—or local—road system. The general assembly clearly hoped to establish the planning and construction of the secondary road network on a more professional and systematic basis.
As a result, counties were required for the first time to prepare county road plans and to have those plans approved by the Iowa State Highway Commission. The road use tax fund was created in Iowa and allocated between the primary and farm-to-market road budgets. The financing of secondary roads was carefully detailed.

As a small part of this overall legislative plan, the general assembly passed House File 54, “An act to establish a fund for financing engineering studies and research projects in connection with the construction and maintenance of secondary roads.” This act, which became Chapter 128 of the session laws and which found its way into Chapter 309 of the Iowa Code, established a permanent fund for highway research in Iowa and dictated how that money was to be spent.

The general assembly, in House File 54, set aside a portion, not to exceed one and one-half percent, of the new farm-to-market road fund to be used for secondary road research. This fund was designated, not surprisingly, the “Secondary Road Research Fund.”

Under the terms of the enactment, the Secondary Road Research Fund was to be used “solely for financing engineering studies and research projects which have as their objective the more efficient use of funds and materials that are available for the construction and maintenance of secondary roads.” The act expressly included bridges and culverts on secondary roads as fit objects for research scrutiny.

Management of both the Secondary Road Research Fund and the actual research envisioned was confided to the Iowa State Highway Commission. The highway commission was to undertake this task in cooperation with the state’s county engineers, although the exact mechanism for this cooperative management was left undefined.

The general assembly provided that an annual report of research undertaken or accomplished would be made by the highway commission to the governor and the county engineers and that a biennial version of this report would be laid before both houses of the general assembly in odd-numbered years. All other details were left to the discretion of the highway commission. The highway commission authorized uncommitted primary funds for primary road research. This allotment, designated the “Primary Road Research Fund,” is authorized annually.

With a structure for research funding now in place, the Iowa State Highway Commission could begin to organize the research of interest to both highway commission and county engineers. The highway commission wasted little time and promptly proceeded with the work at hand. The organization created as a result, the Iowa Highway Research Board, began work in May 1950.
Germination of the Iowa Highway Research Board

To manage the Secondary Road Research Fund and the research envisioned by the Iowa General Assembly, the Iowa State Highway Commission created the Iowa Highway Research Board in December 1949. The Board originally consisted of 11 members serving three-year terms.

Six members were nominated by the president of the Iowa County Engineers Association from among the county engineers of the state. These appointments were made by highway commission districts to ensure that the Board would be geographically balanced and funds equitably apportioned. Three appointments were made by the Iowa State Highway Commission from among the engineering personnel of the highway commission, each nominated by the highway commission’s chief engineer. The presidents of what were then the State University of Iowa and Iowa State College each nominated one member. As a practical matter, these nominations were usually the deans of the appropriate engineering faculty at each school or their designees. Although the county engineers association, the state universities, and the chief engineer of the highway commission were accorded the privilege of nomination, the highway commission retained the right to approve nominations. In practice, of course, none was ever rejected. This arrangement, however, allowed the members of the Board to be described as “consulting engineers” of the highway commission, a designation necessary for the payment of expense money. At the board’s June 1950 meeting, alternate members were appointed by the same process to serve in the absence of regular members.

Early leadership

By May 1950 the first nominations to the Iowa Highway Research Board had been confirmed by the highway commission. The first members were R. E. Robertson, P. A. Michel, C. A. Elliott, J. R. Dougherty, Edward Winkle, and L. J. Schiltz for the county engineers association; W. E. Jones, Bert Myers, and W. H. Root for the Iowa State Highway Commission; F. M. Dawson for the State University of Iowa; and J. F. Downie Smith for Iowa State College.

The first meeting of the Iowa Highway Research Board was held on May 18, 1950. The chief engineer of the highway commission, Fred White, served as temporary chair. The Board promptly elected W. E. Jones as its chair and Bert Myers as vice-chair. Fred White then presented the director of highway research for the highway commission, Mark Morris. According to the organizational plan set up by the highway commission, Morris would serve as secretary to the Iowa Highway Research Board by virtue of his position as director of highway research. Morris held this position for 10 years until his retirement in 1960.
Morris had once been introduced to a convention of the Iowa Good Roads Association as a “walking encyclopedia” of information related to the highway commission, highway construction, and engineering practice in general. A review of Morris’s career shows that the praise was not necessarily hyperbole.

Morris was born on August 9, 1893, near Stockport, Iowa. He attended schools in Bentonsport and Keosauqua and graduated from Iowa State College in 1921 with a degree in civil engineering. Even before he completed work on his degree, he was employed by the Iowa State Highway Commission as an engineer for concrete bridge and culvert construction and for road surveys and plans, and as a materials inspector. In December 1920 Morris was appointed as the research assistant to the engineer of materials and tests. After his graduation, he continued to hold this position. In April 1936 he was appointed director of the state-wide highway planning survey. In December 1938 this position was made permanent, and Morris became the director of planning and survey operations. He also assumed the title of traffic engineer at this time. In June 1950 Morris assumed the responsibility of director of highway research.

In addition to his regular duties, beginning in 1921 Morris was responsible, as special assistant to the chief engineer of the highway commission, for the preparation and presentation of proposed highway legislation to the Iowa General Assembly. In this capacity he prepared reports for the general assembly, such as one discussing the feasibility of toll roads in Iowa in August 1954. He was available for special research projects and was also responsible, along with others, for the compilation and preparation of the periodical revision of the state highway map.

Somehow Morris found time to carry on research of his own. In 1925, for example, he prepared a nationwide survey and report on the performance of highway culverts for the national Highway Research Board. These outside endeavors gained him a national reputation as an expert on concrete construction, and he continued to receive invitations to perform research from other agencies after the formation of the Iowa Highway Research Board.

In August 1954, according to the highway commission’s internal newsletter, the “Employee Information Bulletin,” Morris received the unsolicited offer of a position with the United Nations in Technical Assistance Administration. It was hoped that Morris would bring his considerable expertise in statistics and transportation to bear on behalf of the Republic of Colombia. The Colombians hoped to utilize his skills in the “recommendation and implementation of procedures for the completion and modernization of all statistical data relating to all methods of transportation in Colombia.”
While Morris declined that offer due to the uncertainty of the tenure of the position, October of the same year brought his appointment to a National Academy of Sciences committee to study the effect of jet aircraft on runway pavements. At the same time, Morris was appointed to a National Academy of Sciences panel to advise the government of India on the creation of central research institutes being built with American funds. Morris’s specific function on the panel was to give advice related to highway research facilities.

Amazingly, given his responsibilities at the Iowa State Highway Commission, his private research interests, and his national research commitments, Morris still found time to putter in his flower garden.

When the seed of the Iowa Highway Research Board first germinated in May 1950, Morris played a central role in its cultivation. He advised the Board of the existence and purpose of three research projects then being undertaken by the Iowa State Highway Commission. He served as a contact to enable Board members to compile a list of potential research projects in consultation with the county engineers in their respective districts. He provided information about available funds. He recommended research projects to the Board. Finally, he served as the liaison between the Board and the highway commission.

Selecting the first projects
When the Iowa Highway Research Board was formed, the Iowa State Highway Commission had in hand a few research projects, including an investigation of stream bed scour at bridge piers and a study of roadside seeding, that were taken over and completed under the supervision of the Board. The study of scour at bridge piers, completed as HR-30, led to significant findings cited worldwide and allowed engineers to formulate solutions capable of lengthening the useful lives of bridges.

To create awareness of the work of the Board, Morris circulated a notice of the proceedings of the first meeting. This memorandum went not only to members of the Board but also to all of Iowa’s county engineers. The notice requested that suggestions for research projects be sent to Morris not later than May 31, 1950, for consideration at the next meeting on June 2. Despite the relatively short notice, 17 proposals were received and were discussed at the second meeting. These proposals were as follow:

1. Accelerated testing of highway pavement and bases.
2. Investigation of the loess and glacial till materials of Iowa.
3. Investigation of the supporting strength of concrete pipes.
4. Investigation of motor vehicle operating costs.
5. Origin and destination traffic surveys.
6. Methods for the elimination of long bridges on streams with small drainage areas.
7. Analysis of flood frequency and magnitude.
8. Determination of flood discharge for streams with small drainage areas.
9. Methods to strengthen pony trusses for heavier loading.
10. Treatments for wooden bridge floors.
12. Determination of the necessary thickness for stabilized aggregate bases for use with bituminous surfaces.
14. The hydraulic design of highway culverts.
15. The hydraulic design of highway valley crossings.
16. Investigation of limestone in east central Iowa for low cost road construction.
17. Creation of economical methods of highway construction on earthen fills, with an emphasis on erosion resistance during flooding.

Some of these ideas were committed to special committees for consideration and taken up at another meeting on June 30. Specifically, proposal number two was handled by a committee, seven and eight by another committee, 12 and 16 by a third committee, and proposals six, 15, and 17 by a fourth committee. The remainder were ultimately handed over to Morris for analysis before being considered by the Board.

On June 30, the special committees reported. Items two, six, seven, and eight were recommended immediately as research projects for the Board. The information on aggregate bases requested in item 12 was found to be available from highway commission sources. The Board decided to have the information compiled, Bert Myers having volunteered to do it for the county engineer requesting the project, and then published for use by other county engineers. Item 15 was deferred to a later date and item 17 held for further study.

Morris also analyzed funding sources available to the Iowa Highway Research Board. He advised the Board that over the next three fiscal years he expected the following sums to be available for highway research. From federal sources, he expected $223,837, some of which was to be matched with state funds. The farm-to-market fund, Morris anticipated, would yield $540,000 during the same period, for a total of $763,837. Primary road research funds, also to be administered by the Board, might amount to another $206,000. However, Morris pointed out that funds for highway planning surveys would have to come from this research budget. In the final analysis, Morris expected $180,959 to be available each of the next three years for highway research.

As a result of this flurry of activity, the Board was able to propose six items for funding to the Iowa State Highway Commission. These were promptly approved. The first six projects were the following:

1. Investigation of loess and glacial till materials.
2. Analysis of flood frequency and magnitude.
3. Determination of flood discharge for small drainage areas.
4. The thickness of stabilized aggregate bases to use with bituminous surfacing.
5. Elimination of long bridges on streams with small drainage areas.
6. Highway embankments constructed to resist washout by overflow.

The Iowa Highway Research Board was up and running and moving fast.
Early results
During its first 10 years, the Iowa Highway Research Board undertook dozens of projects. Many of these proved to be of lasting significance. From the start, basic science, engineering, and some other matters of interest to county engineers were examined in research funded by the Board.

Among the first group of projects approved by the Board and funded by the highway commission was HR-1, an investigation of loess soil and glacial drift materials. This work, undertaken by D. T. Davidson, professor of civil engineering, and others at Iowa State College, was initially funded with $45,000 for three years. The investigation consisted of basic soil research similar to that undertaken by the Bureau of Public Roads. Ultimately, the investigation was extended for 10 years and led to significant advances in the field. As will be seen, however, while the work advanced basic science, it was not easily correlated to engineering practice or construction technique, and the difficult and voluminous research came to an end in the early 1960s.

More practical results came from other projects. Two of these projects were the development of sufficiency ratings for secondary roads and the construction of a bridge using aluminum rather than steel in an interstate overpass near Des Moines.

Sufficiency ratings, a systematic method of analyzing the physical characteristics of a roadway along with the area it serves, had long been used by the Iowa State Highway Commission in an attempt to allocate primary road resources on an objective, impartial basis. Despite the utility of such a system for allocating scarce funds, no such system had been developed for local use.

Then in 1956 a controversy erupted in Marion County over improvements proposed for the secondary road system. Several local citizens sought improvements to roads near them. The county board of supervisors, pointing to other roads with an equal or greater need for improvement and assigned a higher priority by the supervisors, declined the request. After some months of unresolved debate, both sides of the dispute appealed to the Iowa State Highway Commission for arbitration. The highway commission had no legal standing to resolve the matter, but both sides sought to enlist the expertise of its staff in determining the worthiness of their positions.

Lacking legal authority, and perhaps sensing political danger, the highway commission declined to judge the merits of the dispute. Instead it suggested that Marion County’s board of supervisors systematize its resource allocation by devising and using sufficiency ratings similar to those employed by the highway commission. This idea seemed acceptable to the disputants. The highway commission also recommended that the board of supervisors prepare a research proposal for the project. The supervisors were thus encouraged to turn to the Iowa Highway Research Board for assistance in creating the sufficiency rating system. Upon receiving the proposal from Marion County, the Board suggested that it be broadened to allow the system to be used by any county in the state, not just Marion County. The highway commission approved this more comprehensive scheme for the research project. Development of the sufficiency ratings system continued until 1960, when a report was given by Mark Morris to the Iowa Conference of County Engineers.

This project was significant not only for its useful product but also as an example of extending state expertise to county government, without state control. Through the
rating system, county engineers and county supervisors responsible for the allocation of secondary road funds were provided with a scientific, objective method for determining the adequacy of their local road networks. Thus armed, boards of supervisors could work towards equitable allocation of funding and planning. No single county could have been expected to undertake such a project, despite its obvious political utility, yet all counties faced similar problems. The work was deemed significant enough to publish, together with exemplary charts, in May 1963 in Highway Research News, the journal of the national Highway Research Board of the National Academy of Sciences. The Iowa system of local sufficiency ratings thus received national exposure.

A project of a different sort was undertaken in 1958 with the construction of the Northwest 86th Street overpass on Interstate 35/80 in Urbandale, a suburb of Des Moines. The construction of the interstate system necessitated the reconstruction of a large number of intersecting streets, and in this instance the Iowa Highway Research Board availed itself of the opportunity for an experiment.

In January 1957 the Iowa Highway Research Board undertook research essentially requested by the highway commission for the study of the use of aluminum in bridge construction. Faced with an ongoing scarcity of conventional construction materials like steel, the highway commission wished to investigate alternatives, including aluminum. It therefore directed one of its engineers, Neil Welden, to investigate the potential for aluminum as a construction material. Welden, although acknowledging that aluminum could be used for construction, was not enthusiastic due to cost considerations.

Despite Welden’s misgivings, the highway commission forged ahead and directed Welden to confer with the design department of Alcoa in Pittsburgh. The aluminum designers assured Welden that aluminum could, in fact, prove a very suitable material for bridge construction. Operating on the hope that aluminum might become economically competitive with steel through frequency of use, the highway commission began working on a research project. The Iowa Highway Research Board supervised the project and was encouraged by a research contribution of
$10,000 by each of the principal aluminum refining corporations in the United States: Alcoa, Kaiser Aluminum, and Reynolds Metal Company.

On January 25, 1957, the Iowa Highway Research Board approved the project as HR-51. The aluminum bridge project was to begin as a feasibility study. If the highway commission decided to continue with the construction of a bridge, that work would also be supervised by the Board. The Board hired Edward Ashton as a consulting engineer for the project and charged him with designing the bridge. When the work proved feasible, the Board proposed locating a prototype as an overpass on Interstate 35/80 in Urbandale.

By October 1957 Ashton had produced three sets of prototype plans: a welded arch bridge, a riveted arch bridge, and a welded girder bridge. The highway commission, less interested in aesthetics than practicality, adopted the low-cost design, the girder bridge, estimated to cost $127,000. Ashton waxed enthusiastic to Morris:

Our design is not a straight substitution of aluminum for steel in a conventional steel beam design but rather it is the most modern welded aluminum beam and concrete floor bridge design that has ever been

Travel by rail
One of four aluminum subassemblies for the Northwest 86th Street overpass is prepared for shipment by rail. Each subassembly required three railroad cars.

The Northwest 86th Street overpass under construction in 1958
A crane lifts the aluminum girders into place.
Germination of the Iowa Highway Research Board

attempted. It is at least ten or twenty years ahead of the rest of the typical conventional steel and concrete bridges that are being built. . . . It is designed in the most advanced fashion . . . to be fabricated from the newest and best noncorrosive structural alloys by the most modern and best of all arc welding procedures.¹

Once the Iowa State Highway Commission approved Ashton’s plan, the U.S. Bureau of Public Roads fell into line and approved the plans by December 1957. The bureau indicated to Morris that interstate road funds for overpass construction would be made available to the highway commission only to the extent of the estimated cost of a similar steel or prestressed concrete structure. The highway commission, Morris advised the Board, proposed to solicit donations from aluminum companies, bridge fabricators, and welding suppliers to make up the difference, which Morris estimated at $47,000, allowing for the construction of an essentially “free” bridge, at least as far as the taxpayers of Iowa were concerned.

Work proceeded quickly. The Pullman Standard Car Manufacturing Company received the contract to fabricate the girders. By June 1958 Morris, Welden, Ashton, and the chief engineer of the highway commission, John G. Butter, were at the Pullman factory in Chicago, inspecting the nearly finished product. Once the Pullman plant completed construction of the girders, the entire structure was loaded onto four flatcars and shipped by rail to within two miles of the site. It was then hauled by truck over the interstate right-of-way and hoisted into place. Work was finished by August 1958, and the bridge was opened and formally dedicated on September 24, 1958.

Despite the novelty and success of the project, the use of aluminum as a highway material remained limited, and only three other bridges using aluminum were built in the country. Shortly after the opening of the Des Moines bridge, New York built two aluminum riveted girder bridges. In 1961 Virginia completed the Appomattox River bridge at Petersburg. However, the price of structural steel fell throughout the 1960s, reducing the need for an alternative material, while the price of aluminum remained high.
Eventually, Iowa’s aluminum bridge became a victim of progress. Although it gave good service for 35 years, the bridge was too small to serve an improved 86th Street interchange and was replaced in 1994.

The final inspection reports for the bridge in the 1980s and early 1990s noted that some cracks had developed in welds. No evidence was found, however, of any cracks or failure brought on by fatigue in the structure itself. Of greater concern were several gouges in the bottom of the girder structure. These were caused by over-height loads scraping the bottom of the bridge. Such gouges, if left alone, might develop into cracks and further damage the structure and were therefore carefully ground out whenever they appeared. Although the aluminum structure was in good shape when it was removed in 1993, the same could not be said for the concrete deck, which had deteriorated considerably over time.

**Passing the flame**

In 1960 Mark Morris retired from the Iowa State Highway Commission. His talent was too valuable to dispense with altogether, and so he remained as a consultant until 1963. During his tenure as director of highway research and secretary to the Iowa Highway Research Board, he had seen the creation and development of the Board. In 10 years, 71 projects had been undertaken, including several of national significance, and the Board had expended $2,700,000.

Morris was succeeded by Stephen E. Roberts. With Roberts, the Board began to develop a systematic agenda for highway research in Iowa, which would mark a new era.
The Justification of Research

Stephen E. Roberts, who succeeded Mark Morris as secretary of the Iowa Highway Research Board, encouraged the Board to move in new directions. Several innovations occurred during his 15-year tenure.

Roberts was born in Burlington, Iowa, on November 10, 1918. Upon his graduation from high school, he attended a business college for one year and then worked in the office of the Midwest Biscuit Company. In 1942 he enlisted in the Army Air Corps and served as a finance clerk in Tunisia, Italy, France, and Germany. The end of the war provided him with new educational opportunities, and in January 1946 Roberts enrolled at Iowa State College in the general engineering program. This curriculum provided no specialization but rather an exposure to a wide variety of engineering disciplines. It proved to be useful training for a research engineer, which is what Roberts became when he graduated from Iowa State College in June 1949.

Roberts was immediately hired by the Iowa State Highway Commission. He began in the materials lab, performing tests. He then worked on special problems and rose to the position of assistant laboratory director. In 1958 he was promoted to materials engineer for District 1. Upon Morris’s retirement in 1960, Roberts was appointed the research engineer.

Roberts encouraged the Iowa Highway Research Board to consider not only the research projects immediately before the Board but also the formation of a research agenda or policy. In May 1960 he suggested that “sometime soon” Board members should discuss the general subject of research and develop some ideas for research in specific areas. Such a formulation of a research philosophy had not previously been explicitly undertaken by the Board. Later that year Roberts would begin the discussion with a summary of his ideas and then encourage members of the Board to respond. His remarks would lead to presentations by members of the Board on the role of the university in highway research, the objectives of county engineers in the conduct of research, and the desires of highway commission engineers in facilitating research. Unfortunately, no extended notes of this last presentation have been preserved in the files of the Board.

The Iowa method of bridge deck repair being demonstrated in the 1970s
This method, which allowed the refurbishing, rather than the complete replacement of bridge decks, generated significant savings of both time and expense.
A friendly debate
In August 1961 Roberts opened the discussion by encouraging Board members to carefully consider the purpose of highway research. The immediate cause for his concern was the appearance before the Board of half a dozen proposed projects which, between them, would consume one third of the available budget. This impelled Roberts to suggest that the Board “review some of the ideas which I believe should be considered in judging the merits of all research proposals submitted to the Board.” Roberts was careful to emphasize that he was merely presenting his personal opinion. The opinions he expressed, he hoped, would provoke members to think about the work of the Board and about highway research overall.

Roberts suggested that research could be justified in at least two ways. Research might be used “in order to increase our knowledge of ourselves and our universe without regard for any immediate application of that knowledge.” By contrast, industry research had as its justification the discovery of new products or improved industrial methods. Research could be justified, then, by either improvements in general knowledge or improvements in practical methods. Roberts noted, however, that highway research funds in Iowa were derived from money dedicated to highway construction. In the final analysis, this fact provided the only possible justification for Iowa’s highway research program. Research sponsored by the Board, to be justifiable, had to contribute to “the construction and maintenance of better or more economical highway facilities.”

With such justification in mind, Roberts suggested that possible research projects could fall into three categories: problem solving, new ideas, and fact finding.

“Problem solving” research could be defined as inquiry aimed at solving perceived shortcomings in existing methods. This research would lead directly to improvements in technique. In consequence, problem solving research proposals were most likely to be justifiable to the Board if the shortcomings in existing knowledge seemed important enough.

“New idea” projects were somewhat more problematic in Roberts’ view. Such projects involved the investigation of materials or methods not presently used in highway construction or maintenance and were more difficult to justify than research designed to solve existing problems. Some proposals could be readily linked to potential improvements in highway construction, but some proposals, while potentially interesting, were too detached from the improvement of the highway program to be justified.

“Fact finding” projects did not necessarily involve engineering problems. Rather, fact finding projects focused on investigating tangential issues to improve the highway program in other ways. The compilation of highway laws, for example, while not leading to the improvement of materials or methods, improved the overall efficiency of highway officials. Other fact finding research could sometimes be justified if the Board felt a need to accumulate knowledge on a subject. The Board had funded such projects in the past and would do so in the future.

Roberts stressed the need not only to carefully justify research expenditures but also to ensure that results found their way into practice. Consequently, the Board might have to fund further development of promising initial research results to guarantee their applicability. For example, the Board might find itself being asked to fund field trials of experimental methods or materials.
Roberts’ suggestions were part of a more extensive effort to systematize the work of the Board. Some proposed projects that could not be justified using criteria similar to those articulated by Roberts were rejected. HR-1, the long-running investigation of Iowa soil types, was ultimately discontinued as having resulted in no applicable results for highway construction.

Discussion of Board methods continued. In May 1964 D. R. Boylan, an alternate member of the Board (and later dean of the engineering school at Iowa State University, previously Iowa State College), delivered a paper to the Board entitled “The Role of the University in Highway Research.” Boylan suggested that the university had a duty to undertake research. He argued that practical research allowed the university to “pay back, in part, the debt that educational institutions owe society.” Despite this obligation, the potential role of the university in highway research offered both considerable potential and severe limitations.

The limitations imposed on the university stemmed from its other role as an educational institution. As a result, Boylan contended, university research was confined to projects that were “a) academically oriented, b) moderately long-term, and c) adaptable to available manpower and facilities.” From the university’s point of view, projects should be suitable for training graduate students or sufficiently novel to entice academic staff. The project should be of sufficient duration to allow for the orderly employment of staff and resources; “crash” efforts were not usually feasible due to preexisting commitments of staff and resources. Finally, projects would have to be structured to take advantage of pre-existing university equipment or funded to allow purchase of all required equipment.

Notwithstanding these significant limitations, Boylan contended the university could still play an important role in highway research. The university was uniquely suited, he said, to serve as a font of new ideas, a source for specialists not usually available to the highway commission, and an institution to recruit and train new research personnel. Boylan pointed out that specialized laboratories such as the hydraulics laboratory at the University of Iowa and the soils, bituminous, and structural research laboratories at Iowa State University had provided valuable assistance to the Board in the past and would continue to do so. He also noted that other departments offered similarly useful contacts.

Boylan concluded by suggesting that the model for further highway commission/university research links should be drawn from the then novel concept of the “research team.” Boylan pointed to the existence of university/industry teams then in operation. The advantage of such teams, Boylan suggested, was that they would allow both the university and the highway commission to draw from their appropriate strengths. The practical result would be that both parties would identify research problems and furnish some of the resources necessary for solution. Boylan cited one example in which Iowa State University supplied personnel and mathematical analysis of data and the industrial partners supplied equipment. Such an approach would move the Board beyond being a patron of research into a more active role.

Input from the Iowa county engineers followed from W. G. Davison, president of the Iowa County Engineers Association. In a paper delivered to the Board on August 28, 1964, entitled “Suggestions to the Iowa Highway Research Board,” Davison offered his views on two questions. First, he asked, “What type projects would be of the most benefit to the Counties for use on Secondary roads?” Second, he asked, “How may proposals for research projects benefiting Secondary roads best be obtained?”
In discussing the utility of topics for research, Davison analyzed the amount spent by counties on secondary road systems. He estimated that maintenance budgets tended to absorb 45 or 50 percent of available funds. Construction, he thought, consumed 40 or 45 percent. Engineering and administration absorbed the balance, about five or six percent.

Davison suggested that this allocation might furnish a guide to the Board’s allocation of resources. If maintenance absorbed a large portion of county budgets, perhaps a large portion of the Board’s attention should be devoted to developing new methods by which counties could economize in their maintenance budgets. Davison conceded that the best way to reduce maintenance costs was to develop better methods of construction. Still, he observed, the study of ways to reduce maintenance expenses, for example by sharing equipment or personnel between counties or between the state and counties, might be worthy of the Board’s attention. In considering such projects, Davison observed, the “main objective should be to provide the State of Iowa with the best overall highway system at the least cost possible.”

Davison noted that the National Association of County Engineers was then engaged in developing a standard for maintenance practices and a manual. He anticipated that this would standardize many operations and result in significant savings for counties. Many research topics would be covered in the manual, and the Board might not find it necessary to engage in duplicate research efforts. Still, Davison anticipated that many questions worthy of attention would remain for the Board.

Construction technique, given the amount of county road budgets that it consumed, would afford another fertile field for Board review. Davison offered three areas of interest related to construction technique for the Board’s consideration. Davison wished to see the Board develop research based on the work of the American Association of State Highway Officials (AASHO) on pavement thickness. He hoped that the Board would investigate the problem of surface types for low-volume roads. Finally, he suggested that the Board should continue to investigate new methods of dust control.

One immediate benefit, Davison argued, could be realized from a thorough Board review of road test experiments conducted by AASHO to determine the applicability of AASHO’s research to local Iowa conditions. The AASHO tests appeared to contradict minimum standards for pavement and base thickness laid down by the Iowa State Highway Commission. State minimums for thickness design allowed for no variation based on pavement type. AASHO experiments, on the other hand, indicated that significant variability in equivalent thicknesses existed. Davison continued, “either the tests were of no value to Iowa, or we should be making use of them. Whichever the case may be, I believe this Board should see that the full information is made available for use in design.”

Another area of research interest, Davison argued, was the economic justification of surface type. Surface types for low-volume roads was an area of interest not only to county engineers but also to city and state engineers. Given the broad level of interest in this subject, it appeared to have promise for Board investigation.
Similarly, Davison continued, the Board would be well served by engaging in further investigation of dust control. Such studies were useful from more perspectives than “the viewpoint of the Monday Washday housewife.” Vehicle safety was implicated if the dust was so intense that drivers could not see.

Less significant achievements were to be gained from engineering and administrative studies, Davison observed. The highway commission expended approximately the same proportion of its budget on engineering and administration as the counties did in those areas. Given that the highway commission had a well developed system for engineering, not much in the way of economy could be expected.

These mundane questions, Davison believed, were of great interest to practicing county engineers working on secondary road systems. He pointed out that significant differences in opinion existed among his colleagues. Research aimed at removing those differences of opinion would be very useful. Davison suggested that such effort should be predominant on the Board’s research agenda. In an implicit criticism of then-pending research proposals, Davison noted that his suggestions might seem “insignificant questions to a Board concerned with such high-minded research as ‘X-Ray Diffraction Studies of Soil and Soil Stabilizers,’ or some of the others recently proposed.”

Davison then turned to his second question, determining the best method for obtaining research proposals that would benefit secondary roads, which he found far easier to answer. He noted that research proposals were easily obtained. County engineers on the Iowa Highway Research Board attended district meetings of their state association at least annually. At those meetings, “shop talk” discussions or more formal presentations generated ideas that were worthy of further investigation. It would be easy for Board members to give presentations at association meetings regarding the then-pending work of the Board and to solicit research topic proposals.

Davison concluded his presentation by praising the Board for the work it had financed in the area of hydrology and structures. He hoped that the Board would continue its fine work in that and other areas. He also promised the support of the Iowa County Engineers Association in ensuring that the Iowa General Assembly made secondary road money available in the 1965 session.

By 1964 the Board found itself seriously in need of the Iowa County Engineers Association’s support to justify its research expenditures; the Board’s authority was undergoing serious legislative attack. **A not-so-friendly threat**

After the Board’s inception in 1949, its statutory authorization had remained unchanged for several years. Then in 1961 the Fifty-Ninth Iowa General Assembly repealed the Secondary Road Research Fund, which funded much of the Board’s research activities. At the same time, the assembly amended Chapter 312 of the Code of Iowa dealing with Iowa’s road use tax fund to include expenditures for research. Assuming that its authority was continued under the revised Chapter 312, the Iowa Highway Research Board continued business as usual.

In 1963 the Board’s authority was called into question by Representative Dewey Goode (R-Bloomfield), who requested an attorney general’s opinion. The resulting opinion effectively eliminated any further expenditures from the road use tax fund for secondary road research; as of January 1, 1962, only primary road research could be undertaken. The opinion stated that unused allocations before that date remained available for researchers at the Iowa State Highway Commission.
This situation continued until 1965. When the Sixty-First Iowa General Assembly met that year, it restored the Secondary Road Research Fund in House File 424 and again, as in 1949, allocated up to one and one-half percent of the farm-to-market road use tax fund for planning and research. Balances left in the fund at the end of any fiscal year could be carried forward into the next year. Since the appropriation was, in effect, open-ended, the highway commission allocated a minimum of $125,000 per year for secondary road research.

Although the general assembly did not long delay in restoring funds after the attorney general’s adverse opinion, the matter was of great concern to the Iowa Highway Research Board. Board minutes during the legislative sessions indicated that regular progress reports were received on House File 424, as well as on a previous, similar bill that failed passage and on a legislative proposal to abolish the Secondary Road Research Fund altogether. The temporary loss of funds impeded some Iowa Highway Research Board efforts. For example, in 1963 counties wishing to participate in a traffic survey to be partially funded with federal matching funds were unable to look to the Board for assistance. Instead, they were compelled to supply their own money in order to qualify for the federal funds.

A productive era
Perhaps as a result of criticism posed by county engineers like Davison, as well as the more aggressive threats posed by legislators like Goode, the Iowa Highway Research Board modified some of its practices. Fewer basic science proposals were approved. The highway commission began to conduct more of its research in house and looked less to outside contractors. Some long-running research proposals that promised better design methods, such as those related to hydrology and flood magnitude, were continued, albeit under greater Board scrutiny. Other projects came under increasingly critical review by the Board and were cut short.

In 1960, even before the Board found itself deprived of Secondary Road Research Fund money, the matter of the long-running project investigating Iowa soil types, HR-1, was taken up by the Board. The result of the project had been similar to the results of soil research pursued by the U.S. Bureau of Public Roads: Much basic knowledge was uncovered, little of which was immediately useful in the design of better or more economical roads. In 10 years, HR-1 had led to the publication of 64 separate academic papers given at conferences or published by the national Highway Research Board or by Iowa State College. Despite this prodigious academic output, the Iowa Highway Research Board had received no final report and had distributed no information related to HR-1 to county engineers and the highway commission staff.

When the project supervisor, D. T. Davidson, requested a funding extension, his request met with stiff opposition. V. R. Bennion, a Board member serving for the State University of Iowa and employed by the U.S. Geological Survey, asked if it might not be possible to begin work on a final report. Davidson replied that this was inadvisable, as much of the research was still incomplete and the task of simply compiling the information gathered to date would require his full time for a year. D. R. Boylan of Iowa State College suggested that a special compilation of the published papers, grouped by subject, might be put together and distributed. M. B. Larson, an alternate member of the Board for the highway commission, pointed out that the object of the research was to make information available to county and highway commission engineers in a useful form. John C. Mors, another Board member, expanded on this theme by pointing out that the act creating the Secondary Road Research Fund directed that the fund was to be used for investigation and improve-
ment of materials used on secondary roads. If that was the justification of HR-1, it was vital that the information gained be put to the test in field trials through the construction of experimental roads. Without such field trials the research was of little use, Mors argued, as the accumulation of knowledge was in itself inadequate. In the end, HR-1 carried on a while longer, although in a much reduced fashion.

Other projects pursued by the Board had happier outcomes.

In November 1960 the Iowa Highway Research Board approved HR-74. This project furthered the construction of a bridge designed to include prestressed steel I-beams. The bridge, the first of its kind in Iowa, was located on U.S. Highway 6 in Pottawattamie County. The highway commission viewed the project as a good opportunity to give as many steel fabrication contractors as possible experience with the new method of construction. To obtain the steel required, the highway commission turned to the Iowa Highway Research Board for the purchase of the required beams as a research project. The balance of the project was handled by the highway commission in the normal fashion.

In 1964, as debate continued over the nature and extent of the Secondary Road Research Fund, the Iowa Highway Research Board approved HR-95, “Repair and Protection of Concrete Bridge Superstructures.” This work was the foundation for later work that resulted in the development of the dense concrete overlay technique, which solved a major bridge maintenance problem, saved Iowa counties and the Iowa State Highway Commission significant monies, and spread across the country.

Ice on bridges had traditionally been combated with salt. This treatment melts the ice but leaves a corrosive salt brine on the road surface. The brine can penetrate concrete bridge decks, causing deterioration of the deck and of the steel reinforcing bars below. Eventually, the whole structure is weakened. Before the findings of HR-95 were made available, such conditions would have led to a bridge’s closure for replacement of the entire deck, at great expense and no small inconvenience to the public.

The bridge research project experimented with a partial repair solution developed by the highway commission’s John Lane and Ed O’Conner. A bridge in Sac County was selected for the test. Instead of replacing the deck, researchers removed concrete to a depth of about a quarter-inch, together with any defective concrete and concrete around the reinforcing bars. The exposed steel was sandblasted clean. A fast-setting concrete was then poured, spread, and smoothed. When the concrete cured, the bridge was reopened for traffic. This method was both faster and cheaper than a complete deck replacement.

The experiment proved successful, and the “Iowa method” of low-slump, dense-concrete deck overlay construction quickly spread throughout the United States. The cost to the Iowa Highway Research Board was $19,000. Vernon Marks, successor to Stephen Roberts as secretary of the Board, estimated in the mid-1980s that the savings to the taxpayers of Iowa alone had been, by that time, about $30 million based on the cost difference then existing between resur-
facing and deck replacement. He also described the work as the single most useful project the Board had undertaken.

In October 1975 the Board had occasion to revisit the issue of bridge repair when the successor agency to the Iowa State Highway Commission, the Iowa Department of Transportation (“DOT”), proposed research entitled “A Bridge Deck Delamination Study” through the Office of Materials. The Iowa Highway Research Board approved the proposal as HR-179. Corrosion caused by salt required periodic inspection for detection of delaminations and maintenance planning. Initially, inspections were conducted by tapping the bridge with metal. Such an inspection required a crew of four people for testing and traffic control, and the entire procedure might take eight hours. The method depended on inspectors’ ability to hear the tapping and so was entirely subjective—an art rather than a science.

In 1975 a firm in Texas offered for sale an electronic device that allegedly could record delamination data for a bridge on a paper chart in one hour. Its curiosity aroused by this claim, the Iowa DOT proposed to phase a prototype for $7,700. The equipment worked, giving rise to a great savings in time and leading to a more scientific method for analyzing bridge repair needs. A subsequent project, HR-269, enabled the computer plotting of the data collected. This saved more time for the bridge maintenance crew by eliminating the labor-intensive mapping of paper charts.

In 1969 the Board approved HR-148, which called for an investigation of pavement wear caused by studded snow tires. Studded tires, useful for winter driving conditions, were first legalized in 1967. The tires quickly became very popular in Iowa and by 1970 were used on over one-fifth of all vehicles in the state. This research project examined pavement wear caused by the tires. The results were astonishing. Based on wear measured during the winter of 1970–1971, researchers estimated that studded tires would be responsible for an additional $140 million in road maintenance on primary and interstate highways over a period of five years. The research did not lead to an immediate ban on the use of studded snow tires, but publication of the discovery—coupled with a legislative attempt in 1972 to seasonally restrict use of the tires, and the introduction of radial tires—was sufficient to discourage public use of the tires, the popularity of which fell precipitously.

New materials were also investigated by the Iowa Highway Research Board. The early 1970s saw an increase in the price of asphalt, causing engineers and contractors to cast about for alternatives. In January 1975 R. P. Henely, the Kossuth County engineer, presented a research proposal to investigate the possibility of recycling
asphalt pavement. Henely proposed to pave a section of road nearly one mile long, widening the shoulder and paving a preexisting 22-foot pavement with a seven-inch thick asphalt surface on a four-inch thick subbase. The old asphalt was to be gathered, crushed, and reused. New asphalt cement, amounting to about one percent of the total to be used, would be added. The old asphalt was to be gathered, crushed, and reused. New asphalt cement, amounting to about one percent of the total to be used, would be added.

The whole project was expected to cost about $98,000, and Henely requested that the Board furnish about $70,000 of that amount. The Board approved the project at a cost of 50 percent of the total, not to exceed $50,000, contingent on the delivery of appropriate plans and specifications by Kossuth County.

This work marked the first of several research projects involving the recycling of asphalt and the performance of recycled asphalt construction. The discovery that asphalt could be practically recycled allowed for significant cost savings. One potential drawback, the copious air pollution caused by the Kossuth County project, formed the basis for a further investigation, taken up in HR-188.

Stephen Roberts concluded his service as secretary of the Iowa Highway Research Board in December 1975. During his tenure, the Board had undertaken many projects of vital significance. It had been expanded in 1969 to include representation for municipal engineers. Extensive discussion of the purpose of the Board and of the purpose of the research it supervised had precipitated the development of a philosophy or research agenda focusing on practical, applied research rather than on theoretical developments. Challenges to the existence of the Board had been unsuccessful. Under the successors to Stephen Roberts, the Board would build on previous accomplishments and continue to fund highway research leading to significant advances in engineering methods.
Chapter 4

The Fruits of Research

In December 1975 Stephen Roberts retired as secretary of the Iowa Highway Research Board. He was succeeded temporarily by Fred W. Walker. Walker had risen to the post of development engineer for the Iowa DOT’s Office of Operations Research. He was, in effect, the number-two man in the department’s research structure. As such, he served as secretary to the Iowa Highway Research Board through all of 1976, until a permanent successor was found for Stephen Roberts.

Identifying useful research

During Walker’s brief tenure as secretary to the Board, Board member R. H. Given proposed in March 1976 that committees be established to seek useful new research proposals. Given suggested that the committees identify research topics in their areas of appointment, define problems associated with the topics, and prepare recommendations for possible research projects based on those problem statements. The research areas that Given proposed for the committees were grading, pavements, structures, and other research. After some discussion of the idea, the motion was withdrawn. The minutes of the Board offer no explanation for the withdrawal; perhaps consensus was reached and formal action became unnecessary. In any event, the committees were ultimately appointed and existed for several years. During those years, the committees suggested several possible research ideas for consideration.

At the same meeting, a general discussion of potential research areas led to four particular items being described as of immediate interest to the members of the Board. These subjects were pavement markings, the utility of slurry coats, macadam shoulder construction, and the effect of one type of seal coat aggregate. The Board decided to actively solicit research proposals in those areas.

Proposals for research in these areas quickly followed. At the April 1976 meeting, research proposals for each area of interest were proposed by members of the Board. The investigation of the slurry seal coat was the first of the topics to be reduced to a proposal and discussed, with Board members relying on Iowa DOT staff for further preparation. Funding was approved, and both the University of Iowa and Iowa State University were invited to apply for the grant. Iowa State University ultimately conducted the survey. During Walker’s brief tenure, the foundation was thus laid for some significant studies and for a new way of bringing research ideas before the Board.

Vernon Marks
Marks succeeded Stephen Roberts and the interim secretary of the Board, Fred Walker, in 1977. During Marks’ tenure, many advances were made in construction methods and in ways to apply computerization to highway research and construction.

Slurry seal in progress

In 1976 experimentation concerning the application and utility of slurry coats was a subject of interest to Board members. The Board funded several projects involving the use of the technique.
Computers and more

By December 1976 the permanent replacement for Stephen Roberts had been hired, and Acting Secretary Fred Walker was replaced by the new research engineer, Vernon Marks. Marks would serve in that post for 21 years, from January 1977 to June 1998.

Marks was born on May 30, 1936, at Ord, Nebraska. When he was four his family moved to Iowa, settling south of Des Moines. He graduated from Indianola High School in 1955, and from Iowa State University in 1960 with a bachelor of science degree in civil engineering.

After a year in California as engineer-in-training for the County of Los Angeles Road Department, Marks returned to Iowa where he became the assistant materials engineer at the Iowa State Highway Commission’s district office in Atlantic. In 1967 he moved to the department’s central offices in Ames. There he served as special investigations engineer, specializing in pavement evaluation, testing, and management, until he was appointed research engineer in 1976.

Marks believed that engineers should always be looking for innovative ways to improve quality and reduce costs. That conviction, together with a natural curiosity and a strong work ethic, earned Marks a national reputation as a diligent and productive research engineer. From 1988 to 1994 he chaired the Transportation Research Board’s Committee A2H03 on Mineral Aggregates; he has served on several National Cooperative Highway Research Program project panels; and he has been an active participant in national expert task groups and Transportation Research Board councils.

During his tenure as secretary of the Iowa Highway Research Board, the Board would undertake many projects of profound significance. It would develop new tools for use in the computer age. It would adapt new technology for the testing of materials and for the construction of roadways. It would face new concerns and move into completely new areas, such as legal research. And it would explore policy issues and issues concerning the well-being of the engineering profession. In 1989, the Street Research Fund was created for the conduct of research relating to city streets.

The late 1970s and 1980s saw increasing use of computers in all aspects of life. The Iowa Highway Research Board had long supported research that extended the computer “revolution” to engineering work, especially county engineering. As the 1980s progressed, the Board became more involved in computerization and technology research. Many of these projects led to computer programs that improved the productivity of engineering staffs.

By the time Marks assumed duties as the Board’s secretary, the Iowa Highway Research Board had already sponsored research on a computerized program to assist the hydraulic design of culverts. In 1968 the Board had sponsored HR-143, a computer program to determine the amount of cut or fill required by a project from field observations. In September 1980 some refinements to the program were proposed. The object was to allow the program to calculate changes in grade and elevation and to allow data for different types of pavement surfaces to be used. This project took some time to come to fruition.

In September 1983 a sweeping proposal was made to develop, test, and evaluate computer applications for use by highway agencies. The proposal included efforts to train county engineers and their staffs in the use of the programs developed or tested. Several specialized applications emerged as a result of the Board’s effort. One example of such work is HR-284, which developed a set of spreadsheets specialized for use by county engineers and another spreadsheet for hydraulic calculations.
Beginning in 1988 Iowa Highway Research Board funding enabled researchers to find new ways for both the Iowa DOT and county and municipal engineers to take advantage of global positioning systems (GPS) and geographical information systems (GIS) technologies. Projects were funded that used these new technologies for improved mapping and surveying efforts.

More computer research proposals followed in the 1990s. Proposed federal standards in 1991 led to the development of a bridge maintenance management database designed to allow for the efficient allocation of maintenance resources.

In September 1992 HR-345, a proposal to develop an electronic bulletin board for Iowa’s county engineers, was approved. The system allowed the Iowa DOT to post bulletins and updates and to furnish resources electronically. County engineers could communicate with each other, as on any other bulletin board, and post questions. The Board hoped that the accumulated responses would furnish a valuable reference guide in its own right. The project started slowly as a test but steadily grew in popularity until it was replaced in 1998 by an Internet service, the Iowa County Engineers Association Service Bureau.

Legal issues
The Iowa Highway Research Board had always funded projects concerned with law. In fact, one of the early projects by the Board in the 1950s was a compilation of Iowa’s state highway laws. That compilation having proved popular, a codification of the state drainage laws was undertaken. Compilation projects continued to be funded periodically thereafter. The assistant attorney general for the Iowa DOT periodically obtained grants from the Iowa Highway Research Board to prepare revisions of the state traffic law compilation. The state drainage law, perhaps being less fluid, was not recompiled. To these works were added two more projects supervised by the Board: manuals for the guidance of county and city officials generally, and engineers in particular, regarding condemnation policy and practice. These manuals were designed to explain the very complex subject of eminent domain to county engineers dealing with right-of-way acquisition.

Another legal subject of interest to the Board was the increasing liability for maintenance practice on highways. With the abolition of sovereign immunity in the 1960s, political subdivisions became inviting targets for much tedious litigation. Finding new ways to defeat litigation became a favorite topic for Board investigations. The first such study, HR-204 in June 1978, was initially entitled “Corrective Action by Counties to Minimize Potential Liability for Highway Accidents.” On the advice
The Fruits of Research

Chapter 4

The county engineering profession

The Board undertook some efforts aimed at the well-being of the engineering profession as a whole. The job satisfaction of public engineering was examined. A study aimed at finding ways to bring women and minorities into the engineering profession was undertaken. The role of the engineer in the county decision-making process was examined. In 1994 the Board began to fund the expenses of two county engineers to attend the national Transportation Research Board’s (previously the national Highway Research Board) annual meeting in Washington, D.C. It was hoped the trip would expose the engineers to national research and increase interest in the subject. It was also hoped that the engineers would obtain new professional contacts, exchange ideas, and begin to formulate research proposals on their own. This program has been a great success and very economical.

Other projects

Several proposals for basic research, albeit using some very complex technology, were also presented to the Board throughout Marks’ tenure. An extensive study of ice removal led to several projects and proposals. The work began with the question of how plows break and move ice and then developed the first accurate model of how blades clear ice. This research led to further questions until it resulted in a project to design a computer-assisted plow incorporating the new information learned.

“X-Ray Analysis of Carbonate Aggregate to Predict Concrete Durability,” HR-266, provided insight into the properties of a good aggregate for portland cement concrete. This study added considerably to knowledge of the life span of portland cement concrete and allowed for predictions to be made about the suitability of aggregates for a concrete mix.
Another project, HR-380, concerned itself with the curing of portland cement concrete, which had not been well studied. Usually, new concrete pavement was allowed to cure for five to 14 days before being opened for traffic. The length of time was not based on any scientific notion or on any possibility for acceleration. In cases where traffic needed to move immediately, a long curing time was not always possible, and therefore interest in shortening the period was great. Resulting from a need to open a road quickly in Lee County, Iowa, this project developed the maturity method for estimating concrete strength. This method allows builders to shorten the minimum curing time to as little as two days.

Image analysis testing, explored by the Board in HR-396, allowed for better quality control for concrete. Image analysis allowed the rapid examination, quantification, and analysis of any number of subjects. A wide variety of items could be analyzed using the image technology, including air voids in concrete as studied in HR-396.

Finally, HR-401 on the quality of soil used in embankments sought to develop design standards for embankment soil compaction through study of embankment failure and its causes. Classification of those causes could then allow for adjustments to compaction procedures during construction.

In June 1998 Vernon Marks retired after 21 years as secretary to the Iowa Highway Research Board. He was succeeded by Mark Dunn. Dunn was born in Marshalltown, Iowa, on September 9, 1970. Given his talent for mathematics and science, he gravitated towards engineering and received his degree in civil engineering from Iowa State University in 1993. Upon graduation, Dunn began work at the Iowa DOT in the bridge design department where he stayed for five years. Dunn views his appointment to the position of research engineer as fortuitous in that it allows him the opportunity to deal with a variety of different subjects on a regular basis.

At the present time, the Board has active projects in many areas, including embankment erosion (TR-401) and bridge deck cracking (TR-405), which seem likely to yield significant results. Dunn foresees future opportunities for Board research in two areas. The further development of innovations in alternative materials for use in highway construction affords ample scope for research proposals. Also, problems faced by county road departments in the maintenance and replacement of aging bridges during a time of budgetary constraint provide considerable opportunity for work on novel bridge construction and repair solutions. While other areas of research will doubtless come to light, those two fields alone may well engage Board attention for many years to come.
The Dissemination and Significance of Research

Research without dissemination of results is not very useful. Since its inception, the Iowa Highway Research Board has exerted considerable effort to ensure that its work has received the attention of the county engineers for whom the Board was formed. Additionally, the Board has statutory obligations to report to the governor and to both houses of the Iowa General Assembly concerning its work. The Iowa State Highway Commission and its successor, the Iowa Department of Transportation (Iowa DOT), have found it worthwhile to ensure that the Board receives public recognition for its work. Board members and Iowa DOT research directors present research at professional conferences. Other professional contacts have developed to allow the Board to both receive and deliver information.

Getting the word out

In the Board’s early years, county engineers received information resulting from Board projects in the form of bulletins. The first of these bulletins was a survey of loess soil literature. Others followed. Occasionally, the Board would publish the bulletin. At other times, the agency conducting the research would publish the bulletin. Additionally, Board projects quickly began to be discussed at meetings of the Iowa County Engineers Association. At the December 4, 1951, Board meeting, the Board was asked to furnish a half-day program for the association’s conference. Four papers were selected for presentation. D. T. Davidson gave an address on HR-1. V. R. Bennion reported on the determination of flood discharge, work derived from HR-3. HR-7, a proposal for a test track, was discussed by Ladis Csyani. Mark Morris discussed Maryland’s system of test roads.

Reports to the governor and the Iowa General Assembly furnished another source of information about Board activities. These reports summarized each project then underway. The cost of each project was noted, together with its funding source. Investigators were noted, as were the accomplishments of the program and its budget.

The work of the Board initially received some public attention. In December 1950 one Board member attended an Iowa Good Roads Association convention and delivered a report on the work of the Board. This was followed by questions from city engineers about the possible participation of municipalities in research. Another member, Ladis Csyani, appeared on WOI television at least twice in the early 1950s to demonstrate research funded by the Board. Visits by the Board to experimental construction projects did not go unnoticed. Frequently, members were met and escorted by county boards of supervisors.

Equally significant were highway commission (later, Iowa DOT) attempts to interest the public in the work of the Board. In 1960 research on culverts led to a prominent illustration in the highway commission’s annual report. A description of the savings achieved by the new method accompanied the diagram. Thereafter, research projects calculated to reduce costs to taxpayers or to improve highway safety were routinely included in the annual report of the highway commission.

No passing

The Iowa Highway Research Board funded studies of traffic signs in an attempt to improve highway safety. The “no-passing” sign was an Iowa State Highway Commission invention that gained national acceptance.
Immediately after the Board was formed, it was occasionally visited by engineers from other states seeking information about the formation of similar boards. The Board was visited by officers from both Illinois and Kansas. A member of the British Scientific Mission, although not interested in the Iowa model, sought information about research being conducted by the Board.

The Board also benefitted from others’ efforts to distribute information. In January 1977 the Board received a copy of a training film on the “Iowa method” of bridge deck resurfacing. The film, produced by Iowa State University and financed with Federal Highway Administration funds, emphasized the results of an important Board project and helped disseminate information about Board-sponsored research.

At different times, the Board helped develop training aids and courses. In 1984 HR-267 was completed. The project developed a training course for snow removal operators on secondary systems. Updated courses on construction standards and the conversion of construction standards from English to metric units followed into the 1990s.

Beginning in 1986 the Iowa Highway Research Board also began contributing significant financial support for Iowa’s Local Transportation Information Center (now Iowa’s Local Technical Assistance Program, managed by the Center for Transportation Research and Education) at Iowa State University. This Federal Highway Administration-sponsored center was established to assist with transportation technology transfer to Iowa’s local government agencies. The Board’s funding provided a significant portion of the state and county matching funds required to obtain federal assistance for the program.

Solving problems
Throughout its history, the Board participated in any number of significant project developments, financing the development of new construction methods, new machinery, new maintenance methods, highway safety studies, environmental studies, and dust control methods. The Board helped devise new ways for counties to solve seemingly intractable road problems. Not all the projects led to a useful processes or products, but most were quite valuable.

Among the new construction methods that the Board developed were the use of fly ash in portland cement concrete, the development of foamed asphalt technology, and a recent project to use old railroad flat cars as bridges on low-volume roads. The railroad car project, TR-421, exemplifies the creative work likely to be required of road engineers in the next century. According to the project description for TR-421, Iowa has 27,000 bridges, the third largest number of bridges of any state in the United States, after Texas and Ohio. The vast majority of Iowa’s bridges, some 85 percent, are on secondary roads and are therefore the responsibility of county road departments. As present structures age and require replacement, county road budgets may not be equal to the task given the large number of structures requiring attention. One possible alternative for infrequently used roads is the conversion of railway flat cars into bridges. Rail cars offer the advantages of low cost, ease of installation, durability, and variability of length. One such bridge is already in place in Tama County, and six other states, mostly in the West, have adopted the procedure.

The Board financed a number of new machinery purchases and design developments for the Iowa DOT. In 1979 the Board approved the final report for HR-178 for the purchase and use of the “Road-Rater,” a vehicle used to perform load tests on highways.
In 1984 the Board received a report on an issue that had long concerned it, the settlement of pavement on bridge approaches. The pavement on an approach is susceptible to settlement, while the bridge, built on solid piers, is not. Over time the two surfaces may separate, forming a bump or dip where they had previously been joined. This bump is at the least an annoyance to motorists and at worst a hazard. Before this project, repairs of bridge approach bumps were frequently expensive and time consuming. The Board had undertaken a literature search about bridge approach settlement in 1976 by Fred Walker and Dar Fox. Walker and Fox discovered that while many other road departments in the United States and Europe had considered the problem, none had found a satisfactory solution. Here the matter rested until April 1980, when the Board approved HR-219. By May 1984 the research was complete, and the results indicated that several potential, inexpensive repair techniques existed, the most promising of which is the use of flowable fill.

A study of a different maintenance method was undertaken by the City of Des Moines in 1986 under HR-290, “A Study of Ice Retardant Pavement.” A salt additive for asphalt pavement, “Verglimit,” held some potential for reducing the amount of deicing chemicals used on roadways in the winter. Ordinary traffic use released the salt from asphalt containing Verglimit and left a constant layer of salt on the pavement. Snow, frost, and ice were thus supposed to be removed without effort. The method worked, to a point. While ice formation was impeded, accumulation was ultimately as bad as ever, and the City of Des Moines was unable to reduce the amount of chemicals used on the test area. In addition, during humid summer months the additive caused moisture in the air to condense on the pavement, resulting in a constantly wet surface.

In the field of highway safety, the Board was able to make some significant contributions to the state of knowledge. Three projects exemplify the Board’s role in discovering new ways of making driving safer. HR-184, approved in 1976, and HR-235, approved in 1981, dealt with the utility of rumble strips in preventing accidents. The objective of both studies was to accumulate knowledge about the effectiveness of rumble strips in preventing accidents at intersections.

Repeated failures of contraction joint seals in portland cement concrete pavement stimulated the need for research. From 1978 to 1989, three different joint seal projects—HR-203, HR-276, and HR-318—covered various sealing materials, joint designs, and sawing and sealing techniques and ultimately produced some revolutionary changes in joint sealing in Iowa. Because silicone sealants weren’t performing satisfactorily, HR-318 was initiated to study the performance of preformed neoprene seals. Findings from this project led to changes in sealant material, joint shape, and sawing techniques, as well as to reduced environmental impacts and costs.
and overall improved seal performance. The revolutionary changes—including early, or “green” sawing of concrete, cutting much smaller joints, and filling them with a hot poured sealant—continue to contribute to improved long-term joint seal performance in Iowa.

Environmental concerns increasingly became an issue in the 1970s and 1980s. Many projects revolved around preventing erosion and restoring vegetation. Perhaps the most useful project from a county engineer’s point of view was the creation of a revolving fund to obtain archaeological impact investigations. In 1977 the Board received a proposal noting that the Army Corps of Engineers’ requirement that archaeological investigations be conducted before the corps permitted the construction of roads caused a hardship for counties with insufficient budgets. As a result, the Iowa Highway Research Board created a revolving fund to finance archaeological surveys with the state archaeologist. Counties could borrow from the fund and would be billed for their share. The fund has been increased periodically and still remains as a valuable part of the Board’s work.

Since the 1950s dust control has been a source of interest to the Board. Some dust control projects were attempted in the 1970s. More successful ones in 1986 and 1995 led to better methods of dust control. In 1986 the Board supported HR-297, which promised “Economic Dust Palliatives.” The project relied on a limestone additive that was negatively charged. The additive stuck to the positively charged limestone dust, forming larger particles that did not rise. The final report for the project indicated that treating limestone with the additive resulted in a 30 to 40 percent decline in dust over the long term. The second project, begun in 1995 and followed up with a third project in 1997, involved the use of ground asphalt shingles for dust control. In both cases, a nearly dust-free surface resulted, and two years later the surface treated in 1995 showed no significant increase in dust.

**Learning from “failures”**

Of course, not all promising ideas translated into developable projects. An attempt to build an electronic roadway frost detector was perhaps a bit ahead of its time when HR-187 was launched in 1976. The project was first slowed by a mild winter with very little roadway frost to detect. The device malfunctioned regularly during the next, more severe, winter. The effort was ultimately abandoned.

In contrast, HR-180, also approved in 1976, was nearly a victim of its own success. The objective was to evaluate an epoxy paint used for pavement markings. The paint was believed to be tremendously durable. The paint was made of two compounds that were mixed at application, along with glass beads. First, the equipment spraying the paint malfunctioned, so only one of the compounds could be sprayed for some of the test. By itself, this paint turned black, an undesirable color for traffic markings. During the otherwise correct painting of another section of roadway, the equipment did not move...
in a straight line, and this paint had to be taken up as well. Finally, a third batch of paint was applied correctly and gave good service. The difficulty in sandblasting off the two unwanted sections of pavement markings led the lead investigator to note that the paint, though expensive, “may have some possibilities.” However, the contractor for the Iowa DOT refused to apply more paint, perhaps due to the difficulty experienced with the first two efforts. Another contractor was found after a two-year delay.

Chemcrete, a chemical treatment for asphalt, was experimentally used on roads in Story County, with approval coming in 1980 (HR-226). The Texas-manufactured Chemcrete was supposed to improve the stability of asphalt and prevent cracking. By June 1982 the Iowa DOT’s Office of Materials noted that the material was riddled with large cracks. The final report in April 1984 minced no words. The report indicated that the additive was merely unsatisfactory in one case but actively detrimental in the other. In both cases it would have to be removed and the road rebuilt.
Conclusion

Throughout its history, the Iowa DOT (and its predecessor, the Iowa State Highway Commission) has placed great emphasis on practical research and the improvement of the local road system. The creation of the Iowa Highway Research Board in 1949 may best be understood as symbolic of that dual emphasis.

From its first meeting in 1950, the Board has undertaken innovative work on projects designed to improve the efficiency of both the secondary and the primary road systems. Many of those projects have received national attention, and many resulted in methods that were developed into standard practices. Some projects, like the design and construction of the first welded aluminum girder bridge in the United States, were overshadowed by subsequent events and did not lead to widespread imitation. Other work, such as the partial removal and repair of bridge decks, was quickly and generally adopted by highway departments across the country.

After 50 years of sponsoring important highway research, the Iowa Highway Research Board approaches the twenty-first century with a record of achievement that warrants optimism. Certainly the Board will continue to serve both the citizens of Iowa and the engineering profession with dedication and good judgment.
Comparatively little historical investigation has been undertaken on the subject of highway research at either the federal or state level. Bruce Seely considered the work of the U.S. Bureau of Public Roads between the world wars in a 1984 issue of Technology and Culture. In 1997 Leo Landis examined the role of highway research in the development of the Iowa State Highway Commission in his book Building Better Roads: Iowa’s Contribution to Highway Engineering 1904–1974. Considerable opportunities exist in the field for further research.

Within the Iowa Department of Transportation, a plethora of primary source records is available for scholars. For this work, the Iowa Highway Research Board minutes from 1950 to 1999 were carefully examined and, unless otherwise noted, provided the quotes in this work. The annual reports on research made to the governor and the general assembly were also carefully examined. Early issues of the Iowa State Highway Commission employee bulletin provided considerable information about the career of Mark Morris during his tenure as secretary to the Iowa Highway Research Board. Each research project undertaken gave rise to one or more files, and each project undertaken was also described in the minutes and in the annual reports of the Board. Especially significant projects were likely to be reviewed at least briefly in the annual reports of the Iowa State Highway Commission, at least into the early 1970s; such notices provided insight into the dissemination of research to the public. All of these sources were examined.

Scholars pursuing the subject further may wish to consider the press coverage or public attention given to research over the last 50 years; such a study was beyond the scope of the present work but would be well worthwhile.

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### Appendix A
**Chair and Vice Chair of the Iowa Highway Research Board**

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<th>Year</th>
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Appendix B
Members and Alternates of the Iowa Highway Research Board
1950–1999

Note: The following list of members and alternate members of the Iowa Highway Research Board has been compiled from membership lists kept by the secretary of the Board. Where a county or city is listed, the member was the county or city engineer. Where ISHC or Iowa DOT is listed, the member was an employee of the Iowa State Highway Commission or the Iowa Department of Transportation, respectively. Where ISC or ISU is listed, the member was an employee of Iowa State College or Iowa State University, respectively. Where SUI or U of I is listed, the member was an employee of the State University of Iowa or the University of Iowa, respectively. V. R. Bennion, an employee of the United States Geological Survey, served for many years as an alternate appointed by the State University of Iowa.

S. Akes, Guthrie Co., alt., 1984; member, 1985
D. A. Anderson, Iowa DOT, member, 1977–1992
E. Beisell, Jones Co., alt., 1971–1972
V. R. Bennion, USGS, alt., 1950–1964
R. Betterton, Greene Co., member, 1979–1981
G. Bishop, Jefferson Co., alt., 1994
R. C. Boyd, ISHC, member, 1954–1958
M. Burr, Iowa DOT, alt., 1993–1995
E. T. Cackler, Iowa DOT, alt., 1993
J. C. Calhoun, Madison Co., alt., 1975; member, 1976
G. Calvert, Iowa DOT, member, 1978–1986
D. Campbell, Iowa DOT, alt., 1976
D. Canney, City of Cedar Rapids, member, 1966–1977
C. Caspers, City of Urbandale, alt., 1971–1974
O. Chantland, City of Ames, member, 1965–1974
C. Christensen, Fremont Co., alt., 1982–1983
L. M. Clausen, ISHC, alt., 1954; member, 1954–1961
L. E. Clayton, Jefferson Co., alt., 1953; member, 1954
L. S. Csanyi, ISC, alt., 1950–1957; member, 1958
J. R. Daugherty, Muscatine Co., member, 1950–1951
F. M. Dawson, SUI, member, 1950–1960
J. F. Downie Smith, ISC, member, 1950–1957
R. W. Dutton, Marion Co., member, 1958–1960
C. A. Elliott, Greene Co., member, 1950–1951
J. Erickson, City of Mason City, alt., 1989–1990; member, 1991
F. Farmer, City of Fort Dodge, alt., 1995–1999
A. F. Faul, ISHC, member, 1960–1963
H. D. Floyd, Plymouth Co., member, 1965–1967
J. L. Franklin, City of West Des Moines, member, 1965
J. George, Dallas Co., alt., 1996–1997; member, 1999
C. E. Hales, Lee Co., member, 1961–1963
G. R. Hardy, Dallas Co., member, 1970–1972
H. E. Hickthier, Floyd Co., member, 1957–1959
J. F. Hoag, ISHC, alt., 1957–1959
J. L. Holdefer, ISHC, member, 1962–1964
L. N. Hoppock, Page Co., member, 1963–1965
J. W. Howe, SUI, alt., 1950–1961
C. L. Huisman, Iowa DOT, member, 1980–1984
O. Ives, Monona Co., member, 1984–1988
W. E. Jones, ISHC, member, 1950–1953
R. H. Justen, Johnson Co., alt., 1951, member, 1951–1955
D. Kao, ISU, 1989–1994
R. Kirchner, City of Fort Dodge, alt., 1978–1980; member, 1981–1984
S. J. Klassen, Des Moines Co., alt., 1987–1989
R. Knoke, City of Burlington, alt., 1997–1999
D. Little, Iowa DOT, member, 1999
R. F. Lundy, Commissioner, ISHC, member, 1958–1959
C. Marker, Fremont Co., alt., 1999
L. Mattusch, Clinton Co., alt., 1979; member, 1980–1982
T. Maze, ISU, alt., 1996–1999
M. McClain, Appanoose Co., member, 1987–1992
D. E. McLean, ISHC, member, 1968–1977
H. Melloh, SUI, member, 1961–1965
R. E. Merrill, ISHC, alt., 1959–1966
P. A. Michel, Montgomery Co., member, 1950–1953
F. Moore, City of Cedar Falls, alt., 1977–1978
W. L. Morris, ISHC, alt., 1973–1975; member, 1976
R. L. Murdock, Audubon Co., member, 1969
R. Murdock, Buchanan Co., alt., 1972–1974; member, 1975
B. Myers, ISHC, member, 1950–1959
T. Myers, City of Creston, member, 1998–1999
C. L. Narotam, Iowa DOT, member, 1997–1999
W. Nixon, U of I, alt., 1993–1999
C. E. Olson, Poweshiek Co., member, 1961–1962
D. Osipowicz, Lee Co., alt., 1998; member, 1999
C. Pestonik, Iowa DOT, alt., 1983–1984
P. W. Peterson, ISU, alt., 1972–1988
B. Ridenour, Delaware Co., alt., 1997; member, 1998–1999
E. Rike, Adams Co., member, 1987–1990
Kwan Rim, U of I, alt., 1975–1979
R. E. Robertson, Cerro Gordo Co., member, 1950–1954
W. H. Root, ISHC, member, 1950–1954
H. Rouse, SUI, member, 1967–1972
W. Sanders, ISU, alt., 1989–1994; member, 1995
L. J. Schiltz, Dubuque Co., member, 1950
C. Schmadeke, City of Iowa City, alt., 1983–1988
F. C. Schneider, ISHC, alt., 1954–1956
D. Schoberlein, Humboldt Co., alt., 1954–1956
E. Schornhorst, Buena Vista Co., alt., 1959
W. L. Schultz, Guthrie Co., alt., 1973–1974; member, 1975
R. F. Sears, Monroe Co., alt., 1975
D. R. Shaw, Ida Co., member, 1977–1979
H.S. Smith, SUI, alt., 1965; member, 1966
L. Smithson, Iowa DOT, member, 1996–1999
L. Stevens, City of Oskaloosa, alt., 1988; member, 1989–1994
J. L. Stober, Chickasaw Co., alt., 1950–1953
C. Van Buskirk, Keokuk Co., alt., 1999
R. J. Wallace, Buchanan Co., alt., 1950; member, 1951
J. Weber, Clayton Co., alt., 1999
W. Weiss, Greene Co., alt., 1997–1999
T. Welch, Iowa DOT, alt., 1999
J. White, City of Dubuque, member, 1975–1976
W. W. Wickham, ISHC, member, 1964–1969
E. Winkle, Osceola Co., member, 1950–1951
R. A. Younie, Iowa DOT, alt., 1997–1999
Appendix C
Iowa Highway Board Research Projects
1949–1999

Dates indicate the years in which projects were initiated.

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<th>No.</th>
<th>Title</th>
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<td>Investigation of Loess and Glacial Till Materials of Iowa</td>
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<td>2.</td>
<td>Analysis of Flood Frequencies and Flood Magnitudes</td>
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<td>3.</td>
<td>Determination of Flood Discharge Characteristics of Small Drainage Areas</td>
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