The Highway Research Board and the Federal-Aid Highway Program

History of a Cooperative Partnership

BRUCE E. SEELY

Since the passage of the Federal-Aid Highway Act of 1916, the federal and state governments have shared the costs and responsibilities of a national highway program. One product of this cooperative administration has been highway research, which has been largely funded and guided through the federal-aid highway program. This broad-based, cooperative research program has generally produced the roads the United States has needed. However, occasional problems of dissemination of information and coordination remain. Strengths and weaknesses of the cooperative research partnership, particularly through the 1960s, are examined here, and the influence of Thomas H. MacDonald, chief of the Bureau of Public Roads (BPR) from 1919 to 1953, is traced.

Federal Aid and the Emergence of Highway Research

By the turn of the century, few industries had recognized the practical value of the systematic application of scientific and engineering research. The highway field was no exception. Roads outside most cities were in horrible shape, yet even in the few states that formed highway commissions before 1905, untrained local officials continued to build and maintain roads according to traditional rules of thumb. Highway research was nowhere to be found.

Bruce E. Seely is associate professor, Program in Science, Technology, and Society, Michigan Technological University, Houghton.

The Changing Face of Research

This picture began to change by 1915, as state highway departments run by engineers were established in every eastern state. Administrators in a few states—California, Illinois, Maine, Pennsylvania, and Virginia—had listened to advice coming from the Office of Public Roads (OPR), as the BPR was originally called, and established testing facilities capable of performing simple research, usually tests of materials. A few trade and professional organizations, including the Association for Municipal Improvement and the American Society of Civil Engineers, began investigating road materials after 1910, as did the engineering experiment stations organized on land-grant college campuses after 1905. Taken together, however, these efforts were modest.

The only systematic highway studies of this period were conducted by the OPR. After the creation of the OPR in 1893, federal engineers began collecting and publishing data on road materials and construction methods. In 1900, engineer Logan Page established a chemical and physical testing facility where more than 1,000 samples soon were tested annually. Page, who headed the OPR from 1905 to 1918, encouraged field investigations, expanded the OPR's object-lesson program of short demonstration projects, and issued sample material specifications. In 1910, the OPR built a full-scale testing facility in Arlington, Virginia, the forerunner of the Federal Highway Administration's Turner-Fairbank Highway Research Center. To expand the OPR's limited resources, Page organized joint investigations with professional groups such as the American Society for Testing and Materials. This cooperative approach became a hallmark of OPR

activities, but only after 1915 was such work termed "research" in the OPR annual report (*1*).

Rise of Modern Highway Research

Modern highway research began with the passage of the Federal-Aid Highway Act of 1916. The act gave the OPR more money for practical investigations. It also provided incentive for expanded state research: federal engineers made the existence of testing laboratories in state highway departments a minimum requirement for receiving federal matching funds. An OPR study in 1918 found only nine highway departments that had full-scale testing labs; six others used facilities at state universities. By 1925, however, every state had access to testing laboratories, more than half of which met minimum equipment standards. The change was attributable to federal-aid guidelines.

Routine testing, however, is not the same as research, a point recognized by MacDonald, who became chief of the newly renamed BPR in 1919. Head of the Iowa State Highway Commission for 13 years, MacDonald was a firm believer in the cooperative research undertaken by Page, his predecessor at the OPR. Events unfolding in the early 1920s reinforced MacDonald's beliefs. First, the importance of science during World War I prompted a dramatic rise in scientific research, as the number of research laboratories rose from 500 in 1920 to almost 3,000 in 1930. The expansion of highway research during the 1920s paralleled this explosion in overall scientific research. Second, public appreciation for scientists rose sharply after 1920. MacDonald believed that engineers would receive the same recognition only if they, too, embraced scientific research. Finally, the type of cooperative research conducted by the BPR was in vogue. Not only had the war demonstrated the value of government/business cooperation, but through the 1920s, Commerce Secretary Herbert Hoover urged business and government to become partners in problem solving, using trade associations as liaisons. Cooperative research was the most important of these "associative" activities, which blossomed after World War I.

TEXAS A&M UNIVERSITY ARCHIVES

Thomas MacDonald, chief of BPR from 1919–1953 and leading architect of the cooperative approach to highway research.

Developments in the highway field also supported MacDonald's call for genuine research. In late 1917, convoys of trucks loaded with war materiel destined for France drove from Midwest factories to East Coast ports. Although this demonstrated the capability of trucks, the convoys destroyed hundreds of miles of roads, including brand new highways. These pavement failures and the slow start of federal-aid highway construction prompted congressional attacks on the federal-aid program. As a result, MacDonald considered research projects vital to the BPR's future, believing that explanations derived from research would demonstrate the BPR's importance and silence congressional critics. In other words, scientific research could solve political as well as technical problems.

Broadening Research Efforts

In 1919, MacDonald launched an expanded highway research program at the BPR that investigated every area of construction and highway administration over the next two decades. The BPR dominated the field until World War II, frequently spending half of the available highway research funds. The data in Table 1 show highway research funding and expenditures. Many BPR research projects sought to place roadbuilding on a systematic footing, trying where possible to replace rules of thumb with more scientifically derived information. Investigations of vehicle impact initiated in 1919, for example, laid the foundation for soil mechanics in the United States.

BPR administrators continued to stress cooperative research. Joint projects with state highway departments were encouraged, to strengthen state research programs. Classic examples were studies of pavement failure by the Illinois Division of Highways and the California Highway Department from 1920 through 1922—the Bates and Pittsburg Test roads. The BPR advised both departments and provided equipment for the tests; the results prompted use of thickened-edge concrete slabs and avoidance of clay subsoils. Numerous other investigations were conducted with state highway departments during the 1920s and 1930s, with the BPR providing the funds and expertise the states lacked. Moreover, MacDonald continued Page's pattern of working with professional and trade associations and universities. Construction of low-cost rural roads and drainage culverts, bridge design, and use of construction equipment were examined under collaborative projects.

BPR research funds were spread widely as it launched cooperative projects with

TABLE 1
Highway Research Expenditures

YEAR	TOTAL FUNDING	BPR EXPENDITURES
1920	$475,000	$175,000
1928	$755,000	$400,000
1931	$1,000,000	$600,000
1932	$838,000	$627,000
1937	NA	$950,000

highway departments (18 in 1928 alone), universities (Ohio State, Purdue, Kansas State, Iowa State, Texas, Illinois, Maryland, Massachusetts Institute of Technology, and Georgia), and trade and professional groups (ASTM, ASCE, National Paving Brick Manufacturers Association, National Crushed Stone Association, Portland Cement Association, Asphalt Institute, and others). It was noted in the 1922 BPR annual report that, "To some extent, the Bureau has been associated with practically all of the major investigations in progress." At the same time, cooperation increased the proficiency of other research agencies. Symbolizing this change, a modern highway laboratory opened in 1937 in Nevada, a state with one of the lowest road mileages.

PUBLIC ROADS

Section of road near Canandaigua, New York, destroyed by seven-ton trucks during World War I.

Role of the Highway Research Board

Another aspect of the BPR's emphasis on cooperation was the creation in 1920 of the Advisory Board on Highway Research. This organization became the Highway Research Board in 1924 and then the Transportation Research Board in 1974. It was formed to resolve potential difficulties facing research within the decentralized federal-aid structures. The most acute problems involved coordination of research to avoid duplication of effort and to disseminate research findings. In 1919, MacDonald, wary of appearing to dictate policy to the states, refused to assign these tasks to the BPR. He proposed instead that the National Research Council house a coordinating agency, and others agreed. The initial meeting of the Advisory Board in 1920 attracted representatives from trade associations, industry, government, and universities. They agreed that the Board could suggest topics for study but that others would undertake the actual research and that the Board would hold annual meetings, conveying results in published proceedings. This cooperative framework for the Advisory Board perfectly complemented the federal-aid highway program.

Yet the HRB in this period was hampered by the conflicting demands of cooperation and coordination. No one wanted the HRB to direct the research community—it was to depend on voluntary cooperation. The HRB's founders changed its purpose from "coordinating" to "correlating" research to reinforce this point. But this also limited the HRB's ability to provide effective leadership, and the *Engineering News-Record* complained in 1924 that the HRB "seems always to have performed a detached function in the road industry."

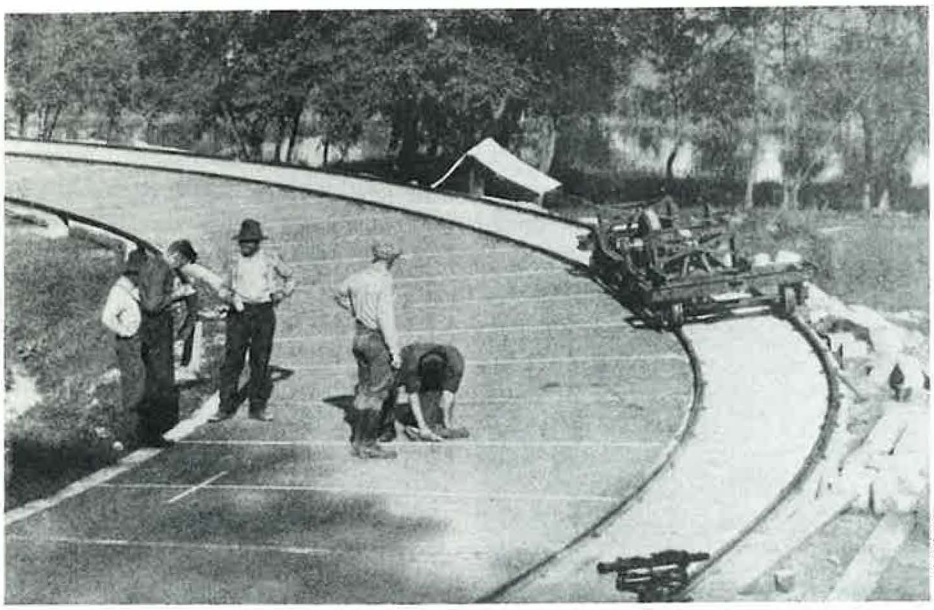
A central difficulty was that the HRB lacked the resources to act independently. Indeed the BPR provided 62 percent of its budget from 1922 through 1945, as shown in Table 2.

The HRB depended on the BPR in other ways as well. For example, the HRB's first secretary and author of its bylaws was from the BPR, as were 2 of the first 6 committee chairmen and 9 of the first 50 committee members. This pattern continued into the early 1950s. MacDonald also worked closely with HRB directors W. K. Hatt, Charles Upham, and Roy Crum while serving on the executive committee, and in 1921 Hatt explained, "I have been depending upon [MacDonald] very largely for direction from time to time." MacDonald not only suggested research topics for many years, but also influenced HRB policy. From the outset he argued that members should be drawn from government agencies, professional and technical societies, universities, and trade associations to ensure that the HRB could remain impartial. The executive committee agreed and in 1920 refused direct corporate funds. When Upham proposed in 1926 the use of funds from commercial sources to support an HRB research staff, the executive committee "deemed [it] inappropriate." A year later, Upham's plan for industrial contacts also was rejected. MacDonald's ideas prevailed throughout (2, 3).

Even so, the HRB was more than MacDonald's mouthpiece. Precisely because of its links to the federal-aid highway program, the HRB eventually became the primary forum for discussing the problems facing roadbuilders. With growth came more committees studying

TABLE 2
BPR Support of the Highway Research Board
Selected Years, 1922–1970 *(2, p. 136)*

YEAR	BPR FUNDS	TOTAL HRB BUDGET
1922	12,000	14,500
1925	12,000	20,930
1930	15,000	24,709
1934	15,000	20,672
1936	20,000	32,494
1940	20,000	35,045
1945	20,000	39,974
1946	20,000	107,863
1948	20,000	134,722
1951	30,000	183,837
1956	36,000	251,800
1958	45,000	308,519
1960	56,250	420,030
1961	61,875	454,562
1962	86,875	759,147
1965	156,375	900,126
1968	322,625	1,376,000
1970	322,625	1,675,000



Experimental pavements on testing oval in Arlington, Virginia. Machinery was used to test pavement wear.

highway problems. In July 1922 the Board sponsored its first conference, on the tractive resistance of roads. It launched its own research effort with a study of rural roads in 1924, and HRB investigators studied concrete reinforcement, soil stabilization, highway safety, and several other subjects during the 1930s. Typically, however, the HRB worked through committees of researchers from around the country; in 1940, 52 project committees with 19 subcommittees tackled such issues as soil mechanics, improved accounting practices, and highway economics. In short order, HRB annual meetings became the premier event for highway researchers, as participation rose from 30 in 1922 to 273 in 1924 to 580 in 1939. (By 1990, registration had surged to more than 5,000.) An *Engineering News-Record* editorial in 1934 indicated how the HRB had changed: "Cumulative growth presents no dramatic moments. . . . This has been so with highway research, for which throughout a decade the Highway Research Board has been a center of crystallization."

Highway Research Since World War II

By the late 1930s the increasing maturity of the HRB was evidenced by the displacement of BPR engineers on HRB committees by state highway and trade association researchers. This development also offered proof that MacDonald's effort to build a highway research community had succeeded. Changes in the federal-aid program continued to encourage this trend. First, the Hayden-Cartwright Act of 1934 permitted highway departments to use 1.5 percent of federal-aid allocations for traffic surveys, guaranteeing funds to stabilize state research organizations. The 1944 highway bill included a provision that allowed states to use funds for research. The American Association of State Highway Officials requested that the HRB coordinate these expenditures, and the Highway Research Correlation Service was formed in 1945. The program increased the states' role in research and afforded the HRB a larger and more certain budget. From 1946 to 1970, the BPR provided only 16 percent of the HRB's funds even as the Board coordinated every major highway research study—the Hybla Valley study, Road Test One, and the Western Association of State Highway Officials and AASHO Road tests. Cooperative research and the HRB both worked as planned. It is a testament to MacDonald and others who shaped cooperative highway research that today the TRB continues to function much as its founders had envisioned (2).

Limitations of Coordination

One less positive legacy of cooperation remains—the accompanying problems of coordination. The very growth in researchers and money ($140 million was available in 1988) that marked the success of the program made operating a voluntary, cooperative research effort more difficult. Another consideration that has assumed more importance in recent years is the need to ensure that research results reach practicing engineers. Papers and publications do not guarantee that results will be used.

The HRB's voluntary nature limited its ability to tackle these problems, which increased with the growth in the number of highway research agencies after 1930. Yet the HRB did not ignore the problems. As early as 1923, Hatt called for an information service. In 1928, Crum began publishing a newsletter that became *Highway Research Abstracts* in 1931. In addition to the formation of the Highway Research Correlation Service, the establishment of the National Cooperative Highway Research Program in 1962 and the BPR's National Program of Research and Development for Highway Transportation in 1965 were responses to calls for better distribution of information. In 1967, the Highway Research Information Service that Hatt had proposed in 1923 finally came into existence in the form of a computerized data base supplemented by regular publications. By 1970 roadbuilders were virtually overwhelmed with too much, rather than too little, information. This in turn brought more calls for better coordination of research as inflation and budget restrictions threatened research programs during the 1970s and 1980s (*4–6*). New efforts at coordi-

PUBLIC ROADS

BPR slab-testing apparatus, 1920–1921, built to determine cause of World War I pavement failures. A weight was dropped from testing tower on sample slabs in an attempt to identify the best materials and construction methods.

nation followed. As was noted in *TR News* only a year ago, "The nation's highway programs . . . need a . . . 'traffic cop' to direct major research activities" (7).

Both strengths and weaknesses in the nation's cooperative highway research program are evident in this brief foray into history. The federal-aid highway program has been central to cooperative research from the beginning, providing encouragement and funding for state highway departments to develop and expand highway research efforts. Similarly, MacDonald nurtured the HRB in an effort to connect all participants in this decentralized system. Steady progress in highway construction and administration has resulted. Yet problems of duplication of research and dissemination of results remain, difficulties that may be the unavoidable price of decentralized research. A strong HRB might have been more efficient but could have threatened the cooperative nature of highway research. In the end, today's transportation research system with the TRB at its center reflects both its origins in the federal-aid highway program and the goals of its founders, notably those of Thomas H. MacDonald.

References

1. B. E. Seely. *Building the American Highway System: Engineers and Policy Makers*. Temple University Press, Philadelphia, Pa., 1987.
2. *Ideas and Action: A History of the Highway Research Board, 1920–1970*. HRB, National Research Council, Washington, D.C., 1970.
3. File 001.11, Classified Central File, 1912–1950, Records of the Bureau of Public Roads, Record Group 30. National Archives, Washington National Records Center, Suitland, Md.
4. T. F. Morf. Principles of Research into Practice. *American Highways*, Vol. 48, April 1969, pp. 6, 35–36.
5. *NCHRP Synthesis of Highway Practice 23: Getting Research Findings into Practice*. HRB, National Research Council, Washington, D.C., 1974.
6. D. J. Kulash. Managing Transportation Research: The Highway Challenge. *Transportation Research-A*, 21A, No. 2, 1987, pp. 153–159.
7. Coordinating Highway Research. *TR News*, No. 143, July–August 1989, p. 22.

The author gratefully acknowledges the support of the National Science Foundation Program in the History and Philosophy of Science.

PUBLIC ROADS

Damage to Philadelphia Pike in Wilmington, Delaware, after passage of fleet of 100 heavy trucks.

Highway Research Today

Highway research in the 1990s remains a cooperative exercise, and TRB continues to be a source of information and a forum for exchange of information. Examples of ongoing cooperative projects and programs among members of the highway community include the following:

Strategic Highway Research Program: A five-year, $150 million research program in which four technical areas are targeted, SHRP is administered as a unit of the National Research Council. Its largest project is the Long-Term Pavement Performance study.

American Association of State Highway and Transportation Officials' Standing Committee on Research: Formed to coordinate the work of state highway departments, SCOR oversees, among other efforts, TRB's National Cooperative Highway Research Program.

Highway Research Coordinating Council: Proposed by AASHTO and organized in 1987 to act as a forum for coordinating highway research activities.

University Transportation Centers: Ten university consortia chosen in 1988 by the U.S. Department of Transportation to receive federal funds to establish multiyear transportation research and education programs.

New England Transportation Consortium: Organized in 1984 to pool the resources of state highway departments and state universities in New England. Membership also includes AASHTO and FHWA. The program is coordinated by the Massachusetts Institute of Technology.

Additional cooperative efforts include TRB's proposed Institute for Strategic Transportation Studies and the National Center for Asphalt Technology, coordinated by Auburn University and the National Asphalt Pavement Association Education Foundation.

Studies of "smart highways" involving industrial and government funds are being conducted by researchers at the Institute of Transportation Studies at the University of California, Berkeley and at the University of Michigan Transportation Research Institute. Other "smart highway" studies include the Texas Advanced Technology Program and the California Department of Transportation's Pathfinder Program.

Finally, the National Highway Traffic Safety Administration and the Division of Injury Epidemiology and Control of the Centers for Disease Control are collaborating on an injury study.