

HIGHWAY RESEARCH IN TEXAS -
SHOULD IT BE CHANGED?

by

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INTRODUCTION

Highway research in the United States and Texas as well has evolved to the present state through the development of the nation's highway system. Problems in the highway industry have supplied more research needs than could possibly be financed.

Objective

The objective of this paper is to document highway research in Texas, cite advantages of the current methodology, and to suggest how it might be changed to obtain more implementable results.

Scope

The history of highway research in Texas is covered from the beginning to the current HPR (Highway Planning and Research) program with a description of the administration of the current program and its methodology of conducting and implementing research. The current methodology is given a critique and specific suggestions are made for changes in the method of continuing the research program.

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HISTORY OF HIGHWAY RESEARCH IN TEXAS

The Texas Highway Department was organized in 1917, but it was not until 1931 that any formalized research was sponsored by the Department. In 1931, The University of Texas, Bureau of Engineering Research conducted a study on aggregates for concrete pavement. Prior to the creation of the Materials and Tests Division (D-9) all soils investigations were conducted by The University of Texas at Austin under the direction of Professor Raymond F. Dawson. In 1932, a research division was established to conduct and handle a large pavement construction and behavior study in Guadalupe County, Texas.

In 1948, a "Research Section" was established in the Highway Design Division, D-8 (then Road Design Division). The first Research Engineer was Mr. Porter Carothers, who was replaced in January 1949 by Mr. Frank H. Scrivner. The objectives of the research section were as follows (Ref 1):

- (1) to aid in developing a practical and reliable method for designing the correct depth of flexible pavement, and to promote the use of such a method by the field;
- (2) same as paragraph one but for rigid pavement structures;
- (3) to facilitate the use of geology by the field in locating material and in design of depth and type of pavement; and
- (4) to aid in the solution of any problems of road design arising from time to time and requiring special investigations or field surveys.

Texas A&M College sent requests to the Texas Highway Department in 1939, 1941, and 1948 to do research for the Department. In 1949, Texas A&M College was designated as a research agency for the Texas Highway Department by House Bill 789 of the 51st Legislature's regular session. By 1952 four research projects were underway with Texas A&M for \$18,000. The testing laboratory of D-9 was by this time also doing research which was not in conflict with that of Texas A&M College.

In 1953, the State Highway Engineer, D. C. Greer, issued Administrative Circular No. 33-53 with the subject of Highway Research and Investigation (Ref 2). This document created a new procedure for handling of research and investigation work of the Highway Department. It also established the Research and Development Committee which consists of the Engineer of Secondary Roads, Bridge Engineer, Engineer of Maintenance, Engineer of Materials and Tests, and the Chief Engineer of Highway Design, who serves as chairman of the committee.

Texas Transportation Institute (TTI) was created in 1956 at Texas A&M College. It was then designated as the research arm of the Texas Highway Department and by 1958 had a program of about \$200,000 worth of research underway financed by federal and state funds.

The Research Digest was started by the Research Section of the Design Division (D-8) to disseminate research results to the field personnel of the Highway Department. This digest is still published, having had very good success.

Highway legislation in 1962 required that 1 1/2 percent of all federal highway funds returned to the states be spent for planning and research. It was at this time that the research program of the Texas Highway Department began to show significant growth. One year after this, The University of Texas at Austin began doing work for the Highway Department under inter-agency agreements. In 1965, the Texas legislature designated The University of Texas at Austin, Center for Highway Research, as a research agency of the Texas Highway Department.

Since 1965 the research program of the Texas Highway Department has been carried on jointly with the Texas Transportation Institute of Texas A&M University and the Center for Highway Research of The University of Texas at Austin. There have been requests of still other universities to get into the highway research program, but these have been unsuccessful. Currently, the U. S. Geological Survey is conducting one research project in the HPR program.

Other Research

The Texas Highway Department participates in still three other research endeavors, these being the National Cooperative Highway Research Program (NCHRP), National Academy of Science's Highway Research Board, and Multi-State Research Projects.

ADMINISTRATION OF THE RESEARCH PROGRAM

Organization

The Texas Highway Department's formal research program is administered by the Engineer of Research who is under the direction of the State Highway

Engineer and the Research and Development Committee, Fig 1 (Refs 3 and 4). The Research and Development Committee is appointive by the State Highway Engineer (Ref 2).

The members of the Research and Development Committee have the responsibilities to conduct, organize, and administer the Cooperative Highway Research Program. They recommend research and development policies and approve advisory committee members.

The research program is divided into four technical areas each of which is headed by a technical advisory committee. The four areas are

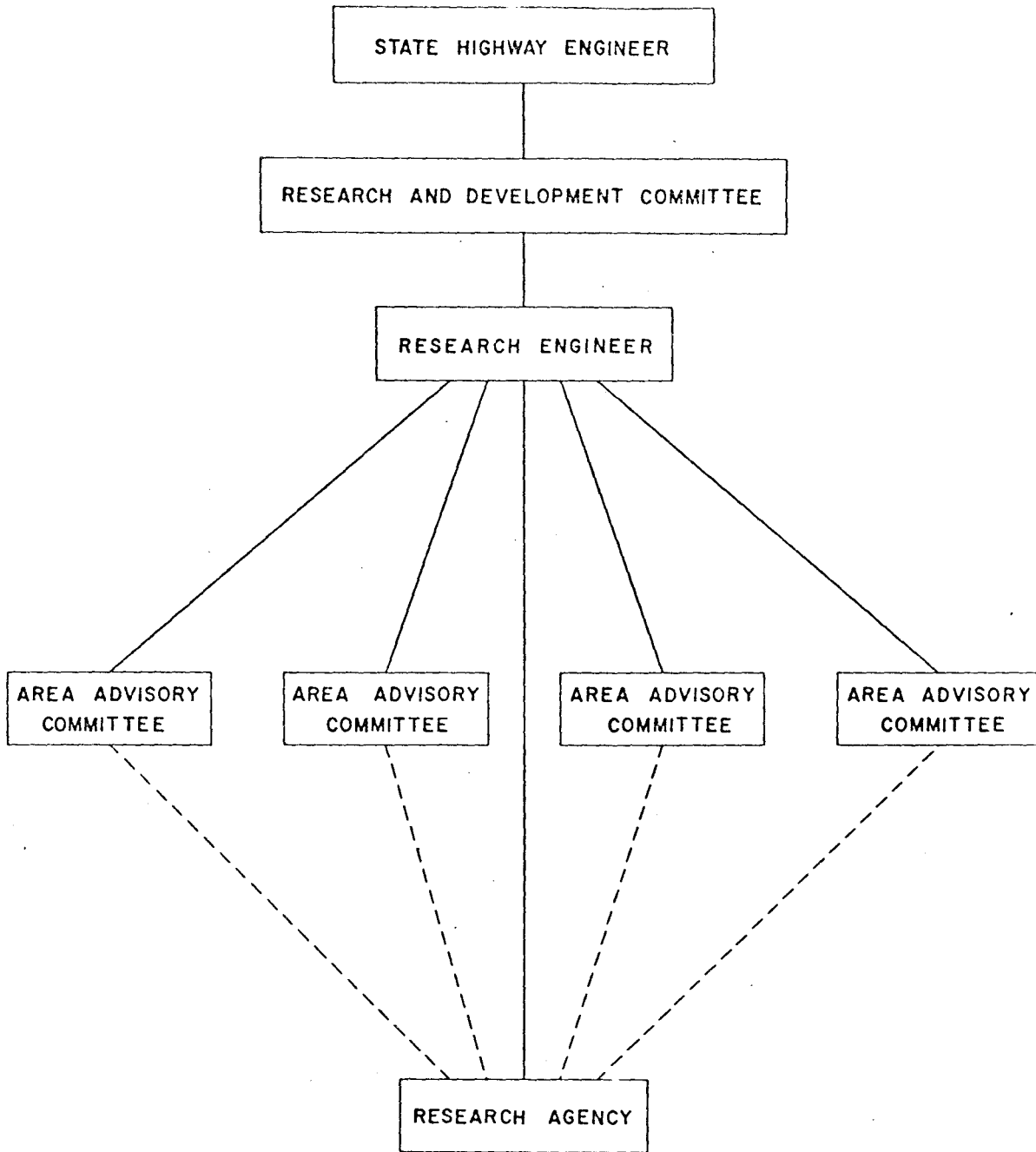
- (1) geometric design, traffic, right-of-way, and economics;
- (2) materials, construction, and maintenance;
- (3) pavement design; and
- (4) structures.

Each Area Advisory Committee includes an area coordinator, who handles all coordination work and acts as secretary for the committee. Figure 2 illustrates how the Technical Area Advisory Committees fit in the organization. These committees give advice to the research studies in their areas. They anticipate and recommend research needs. These committees are made up largely from field engineers and are directly responsible for implementation and application of research results. The committees have no decision-making power with respect to selection of research projects or expenditure of funds, but merely may make recommendations in the form of a committee report or resolution.

In the administration of any one research project, the most important individual is the Highway Department's Study Contact Individual. This individual functions as a liasion individual between the study supervisor and the area coordinator (Fig 2). The contact individual also maintains surveillance of his assigned study always being informed of its objectives, progress, and general direction (Ref 3).

Finance

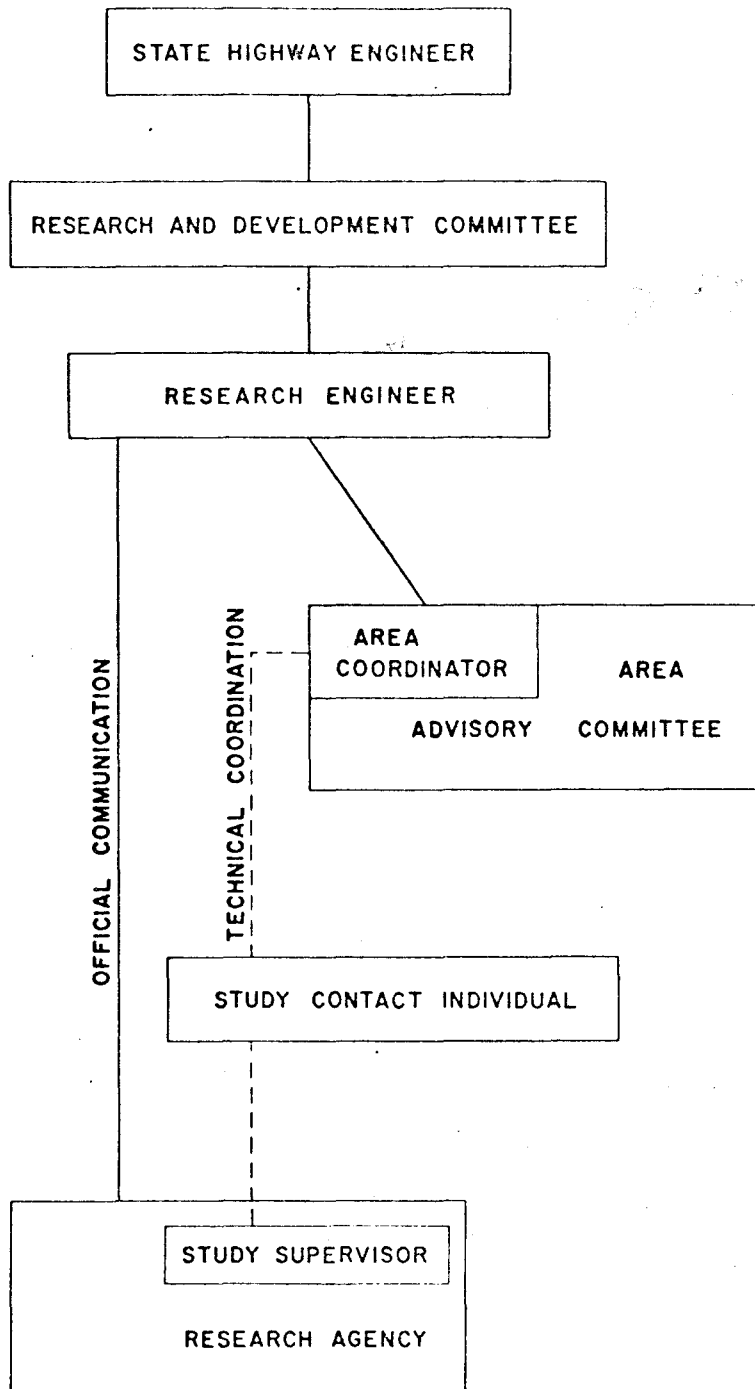
Up to 1956 all research efforts of the Texas Highway Department were financed solely by state funds. On federal and state financed research approximately 72 percent of the cost is covered by federal and 28 percent by state highway funds. All proposed research which is to be partly financed by federal



ORGANIZATION AND FLOW CHART
FOR
COOPERATIVE RESEARCH PROGRAM

Figure No. 1

(from Ref 3)



ORGANIZATION AND FLOW CHART

Figure No. 2

(from Ref 3)

funds must be approved by the U. S. Department of Transportation, Federal Highway Administration.

Each year the budget of the Planning Survey Division (D-10) and the Highway Design Division's Urban Transportation System Planning Section are subtracted from the 1 1/2 percent HPR funds and the remainder is available for the research needs of the Texas Highway Department.

The history of documentable research expenditures are reflected in Fig 3. Three curves are shown, one for departmental research, and one each for Texas Transportation Institute and the Center for Highway Research. The growth of highways in Texas is rather apparent by the monies spent. The growth is attributable to the constant expenditure of 1 1/2 percent of the federal monies for planning and research. Figure 4 shows the total highway construction and right-of-way expenditures with time (Ref 5). The increase in construction and research dollars correlate very well.

Currently in 1970 the estimated budget for the total highway research program is as follows (Ref 6):

<u>Agency</u>	<u>State Funds</u>	<u>Total Cost</u>
Texas Highway Department, HPR-1-10	\$ 90,045	\$ 333,500
Texas Transportation Institute HPR-1-10	351,000	1,300,000
Center for Highway Research HPR-1-10	189,000	700,000
U. S. Geological Survey HPR-1-10	29,025	107,500
NCHRP (Research) HPR-1(80)		190,000
National Academy of Science		53,000
Research Contingency Fund	27,000	100,000
Demonstration Program	<u>13,500</u>	<u>50,000</u>
TOTAL	**\$ 699,570	\$ 2,834,000

** Estimated at 27 percent total cost.

Selection of Research

There are always more possible research efforts than could possibly be financed. Research needs are made known to the research agencies by the respective area advisory committee meetings, thus proposals are invited on selected subjects. The research agencies, however, may initiate proposals on their behalf for consideration by the Research and Development Committee.

Each research agency submits its entire proposed research program to the Highway Department on April 1. Prior to submission each agency generally

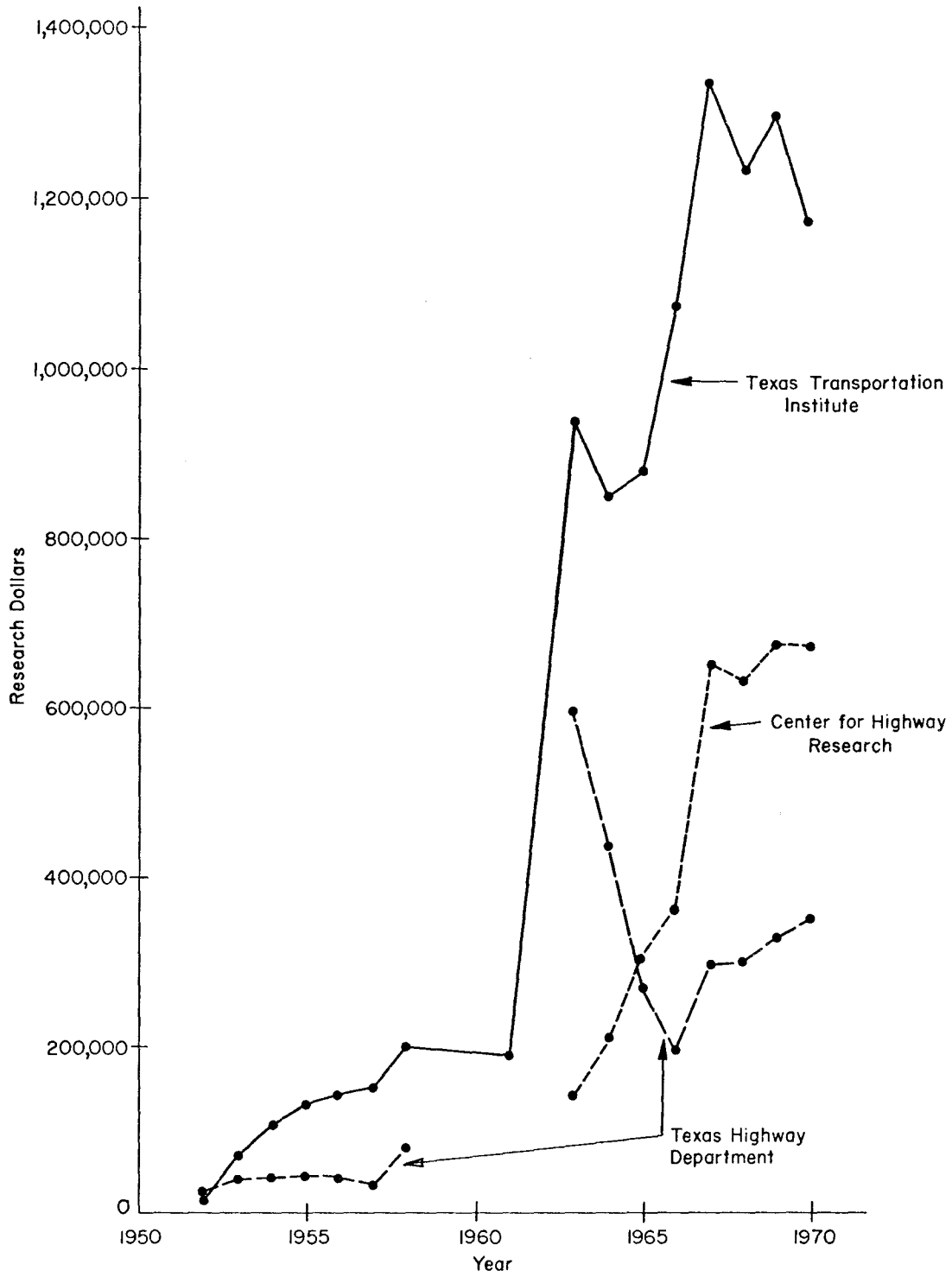


Fig 3. Research dollars spent by the Texas Highway Department and its agencies.

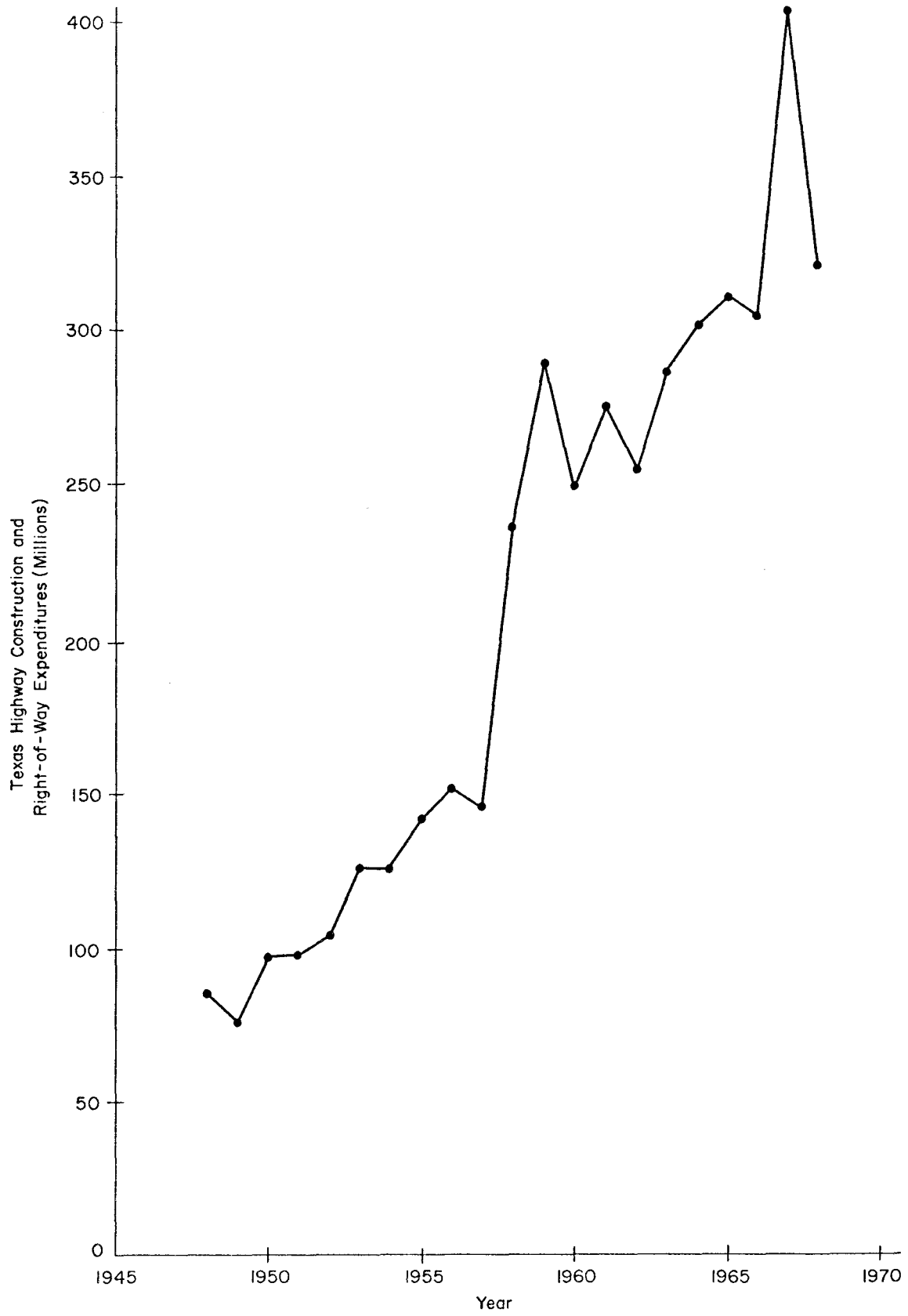


Fig 4. Highway construction and right-of-way expenditures in Texas

knows about how much funding it can expect in the forthcoming year. Each proposed research study is then reviewed by the Highway Department and either approved or rejected by the Research and Development Committee. Those proposed studies which are approved are then submitted to the U. S. Department of Transportation's Federal Highway Administration for approval and funding. Individual research proposals usually receive some revisions prior to funding based on suggestions by the sponsors, namely the Federal Highway Administration and the Texas Highway Department.

METHODOLOGY OF RESEARCH CONDUCT

The methodology utilized by the Highway Department to carry on its research program has been covered somewhat in the coverage of the research history. Currently, in the HPR program there are 48 formal research projects. The research programs are split up in the research agencies and the Highway Department as follows:

<u>Agency</u>	<u>Number Projects</u>	<u>Total Funding</u>
Highway Department	8	\$ 333,500
Texas Transportation Institute	22	1,170,300
Center for Highway Research	17	671,300
U. S. Geologic Survey	<u>1</u>	<u>107,500</u>
	48	\$ 2,282,600

The philosophy which serves as the basis for the current research conduct methodology is the advantage which the Highway Department has in the arrangement. In the current year, 1970-1971, the Highway Department has contracted 85 percent of its research dollars to its designated research agencies for a total of 40 projects, with some in each of the four research areas described earlier herein.

The Highway Department realizes many advantages by contracting its research to its designated agencies. Federal Highway legislation is such that unless the states spend their 1 1/2 percent funds for planning and research, they do not receive the funds for other use. Thus, in 1962, when the HPR program was well underway the Highway Department was able to realize immediate

values from its research dollars by contracting, whereas, if it had not been possible to contract the research, the Highway Department would have had to develop a tremendous, highly specialized research group, which it probably could not have developed under the existent salary and wage job classification. At this same time the Interstate Highway Program was well underway and required practically all the engineering manpower the Highway Department could employ. Thus the current method of contracting research provides for the use of the best technical expertise available in the research agencies. The two universities have available a pool of research oriented professional people with a wide variety of talents. Specialities can be organized reasonably well for specific problems. A problem in the materials field, for example, may well require an input from the disciplines of civil engineering, chemistry, physics, geology, agricultural soil science, and others. A problem in the traffic engineering field may well involve the traffic engineer, mathematician, statistician, and computer specialist. Thus by contracting research the research problems can be more effectively approached by the interdisciplinary team approach.

A second major advantage of the current methodology is that the universities, Texas and Texas A&M, both have very fine facilities for the conduct of research which would not be available to the Highway Department otherwise (Refs 7 and 8). With a research program of almost \$2,000,000 annually in the two universities, the necessary facilities would probably be a practical impossibility for the Department. Highly specialized equipment such as electron microscopes, x-ray diffraction devices, controlled environment chambers, large data processing equipment, spectrometers, and research reactors is found rather commonly on campuses. This array and many other items of specialized equipment may not be economical or practical for the Highway Department to possess for their limited research use. Acquisition of additional equipment by a university is made possible by the use charges paid by the Highway Department for equipment used in cooperative research (Ref 9).

In the cooperative research program the Highway Department benefits directly by keeping its staff in direct contact with university researchers, thus giving opportunity for staying abreast of the latest technological developments. The Highway Department's contact representatives on the cooperative team are responsible for feeding the results of research into the production operations of the Department. They, therefore, have an opportunity to stimulate

innovation. Thus, the Highway Department benefits directly from the research and also keeps from slowing down by lessening staff obsolescence.

An organization as large as the Texas Highway Department which currently employs 1144 professional engineers (Ref 10) needs to maintain a continued recruiting program for engineers to offset retirements, resignations, obsolescence, and increased production needs. The cooperative research program provides jobs for undergraduate and graduate students, thus apprising them of the most current highway technology. These students thus become potential Highway Department engineering recruits. At the same time the cooperative research program makes it possible for interested Highway Department engineers to further their knowledge of the latest highway engineering technology. It is true that some engineers who obtain graduate degrees while employed by the Department subsequently leave. Those that do leave are keenly interested in research and in order to advance in this field the engineer must move from the Department to the university because of the philosophy and method of conducting the Texas Highway Department's research.

It has been said that prior to the Interstate Highway Program much problem oriented research was conducted by resident engineers in the field throughout the state. The money spent for construction and right-of-way through the years is summarized in Fig 4 (Ref 5). In 1956 approximately \$151,000,000 were spent for construction and right-of-way. At this time the Department employed 907 engineers (Ref 10). In 1967 the Department employed 1076 engineers and spent almost \$405,000,000 for construction and right-of-way. Thus, in about one decade the total funds expended on construction and right-of-way increased 168 percent while the increase in professional engineering manpower was only 19 percent. This indicates that there was less time for research in the field or less engineering for the construction dollars. This is not to say that highways were not well engineered, but that more authority was vested in qualified technicians supervising and inspecting construction.

DISCLOSURE OF RESULTS AND IMPLEMENTATION

The fruits of research work must be clearly documented so that they may be used in their appropriate area to change design procedures, design criteria, construction methods, or some other operational problem. The findings have to

be made implementable prior to their presentation to the sponsor. The methodology used to disperse research findings in an organization as decentralized as the Highway Department is very important. Simply making research findings available to operating personnel is usually not enough.

Administration and Methodology

In administering the HPR program the research project supervisors are required to prepare quarterly progress reports, interim study reports, and/or a final report and a summary report for each interim and final report (Ref 3). Significant research findings of major interest to engineers as well as the sponsoring public sometimes receive magazine coverage by such magazines as Texas Highways.

The Texas Highway Department attempts to make use not only of research it sponsors but also that which is sponsored by other states which are participating in the HPR program. This is accomplished through the research services provided (Ref 4) by the Research Section of the Highway Design Division. These include the library service, HRIS, and the Research Digest (Ref 4).

In recent times still other methods have been used to implant research results in the operations of the Highway Department. Training conferences have been held to initiate the use of newly developed computer-aided design aids. These conferences usually include personnel from appropriate Austin office divisions and/or personnel from selected or volunteer districts. In a large, decentralized organization training schools or conferences for all operational arms of the Department are a practical impossibility. Still another method of presenting research findings to the field is the Annual Highway Short Course at Texas A&M University (Ref 11).

Implementation

In order for the results of any research effort to be of any value to the Highway Department they must be implemented in the regular operations of the Department. This phase of research is the most difficult of the entire program. The Highway Department's technical contact representative on each project is the very key to the successful implementation.

The problem of implementation is acute because of the wide cleavage between theory and practice (Ref 12). This problem is added to by four other

problem areas cited by Lewis (Ref 12) as follows:

- (1) the problem of closing the "gap" between what professional engineers understand as theory and what they do in actual practice. It may also be thought of as narrowing the "lag" between research and implementation. This problem, unfortunately, is found among other professional people too in the fields of medicine, education, law, etc.;
- (2) the continuity of effort in identifying and researching the most pertinent problems;
- (3) the problem of determining priorities in terms of the greatest good for the public at large; and
- (4) the problem of involving the maximum number of professional personnel in the program including construction and maintenance people, researchers, planners, designers, and administrators - all consistent with the orderly and efficient conduct of the research program.

Although implementation is hampered by problems such as have been cited, some research findings do find their way to the bloodstream of the Highway Department. These results are implemented by new or revised design procedures, new specifications, revised specifications, use of new materials, etc. Some of the outstanding recent research findings which have been implemented have been in the field of breakaway sign supports, traffic control, skid resistance of pavement surfaces, and pavement design.

Another area of research which often does not receive much attention is the use of research findings in a continuing research program. Much research is dependent on other research findings which provide basic data. This type of research implementation serves as the basis for new technology for use in the classroom.

Much research information particularly in the field of design is implemented in the classroom. Engineering education is continually updated by the injection of new highway engineering knowledge. This benefit of research is somewhat intangible from the Highway Department's point of view. However, an organization as large as the Highway Department which employs in excess of 1100 engineers (Ref 10) must continue to recruit well qualified civil engineering graduates. Numerous engineers of the Texas Highway Department have obtained graduate degrees in their own time which is a form of research implementation.

RESEARCH - SHOULD IT BE CHANGED?

The research program which the Highway Department has today is a very fine program. The highway research program has been very stable as indicated in Fig 5, considering the condition of the nation's economy. In the following paragraphs suggestions are offered which, if implemented, the Highway Department would benefit more directly from its research investment.

The phases of research which should be changed include the selection of research topics, conduct of research, reporting of results and the all important phase of implementation. These changes can only be made possible by the Highway Department. The comment has often been made that research is conducted for the sake of research and that all findings include the need for more research. If this is true, the Highway Department is certainly responsible since it selects the research which it elects to sponsor. This attitude has probably resulted from the lack of implementation of results from research projects. This probably resulted from the early time of the HPR program when there was no competition among research proposals for financing; thus probably some research was sponsored which might have produced unimplementable results, i.e., the balance between theoretical and problem oriented research was not maintained. Thus research which can serve an immediate need of the Department should be made more a part of the program rather than the broad, ensuing projects that cover too wide a part of the highway engineering spectrum.

Conduct of Research

The current method of conducting research is reasonably well balanced in the current program. The method of conducting research is directly related to the type of research being conducted. It was suggested above that more problem oriented research be instigated to solve more of the acute operational problems. To make this possible it will be required of the Highway Department that it do this work with its own forces or maintain a closer working relationship with its research agencies than is currently done with the technical contact representative (Ref 3). The contact representative is not deeply enough involved in the research in order for the Department to obtain implementable results.

Much research in the four described areas has been of a fragmented or piecemeal nature. The systems approach to any problem can yield a coordinated

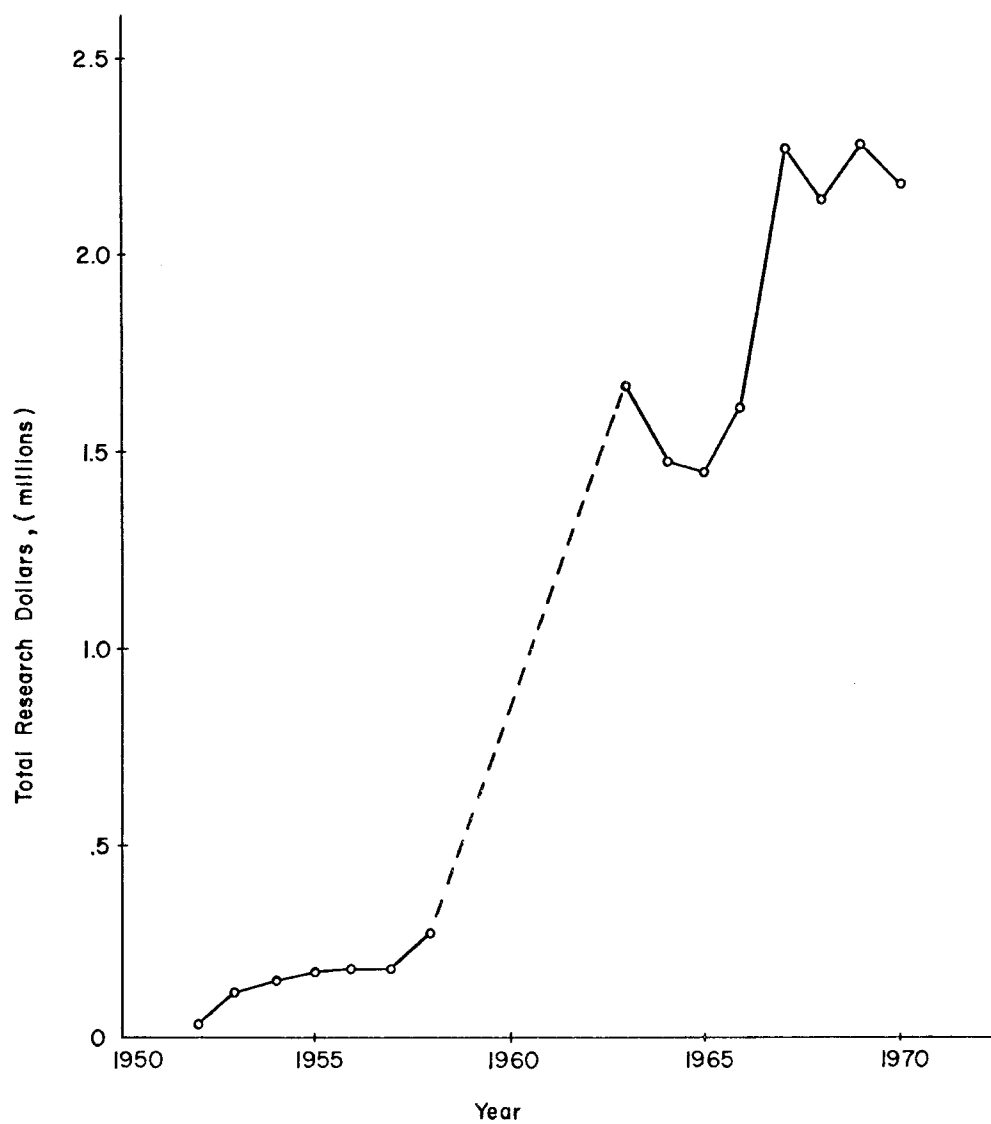


Fig. 5. Total research expenditures of the Texas Highway Department.

effort as has been the case in pavement design (Ref 13). This systems approach could be applied to maintenance problems such as the litter problem as well as other operational and design problems. In the long run a systematic approach should yield more work for less dollars.

Reports

Reports documenting research have drawn criticism for some time. The type of report is very dependent on the type of research. Therefore, a research project on the computer simulation of a bridge component will result in a very complex report, probably meaningless to the average highway engineer. Reports on this type of research must serve as the basis for design guides, not the guides themselves. Theoretical research as it is conducted by the research agencies usually gets little implementation. The work advances the state of the art of the specific subject and the reports are a credit to the researcher, but of little value to the Highway Department. Thus reporting is related to selection of research topics.

The problem oriented or practical research is usually reported in a simple manner which can be read and understood by the average highway engineer. Much of this work is done by practicing highway engineers. When conducted in the overall framework of research needs the problem oriented research yields more tangible, useful results which can be written and illustrated for the practicing engineer.

In general the reports written on highway research are well written documents. These documents, irregardless of the technical content, must be of some value to the Department. Therefore, in these technical areas where types of research are conducted with which the practicing engineers are not readily familiar, qualified personnel should be employed. This may require changes in the current job classifications. Unless the Highway Department employs some of the graduate students doing their work they stand to lose doubly.

Implementation

The last area in which the current methods should be changed are in research implementation. The responsibility for the immediate utilization of research findings for which public funds have been expended rests not with the researcher or the operating personnel of the Department but with the

administration (Ref 14). The administrator must accept this responsibility and set into motion a systematic mechanism that will insure the closing of the missing link and in addition take a personal interest in following through, thus once the system is established, it will continue to function (Ref 14).

Research of common value to more than one state should be utilized to a greater extent. When utilizing federal monies for research and construction certainly problems common to more than one state should be supported by the multi-state method to stretch the available research dollars. Implementation of research findings can thus be accomplished in a widespread manner.

Implementation should be a very important factor in the selection of research for funding. Proposals and reports now require some plan for implementation, but if the Highway Department has not begun to implement the findings prior to the issuance of the final report very valuable time may be lost, but worse, tax dollars may have been unwisely spent.

Implementation of research is the Department's responsibility, therefore on some research projects significantly more work is required of the Department than that which can be accomplished by the contact representative. The contact representative must be directed to be more involved in the research because he is the Highway Department's man on the research project.

The recently developed "demonstration program" has a very high potential for getting research results into the production components of the Highway Department. To the date of this writing only two such projects have been funded. It is recommended that this program be expanded as necessary to utilize completed research because much research which has been completed has been set on the shelf simply because it was not in an immediately useful form for design, construction, or administration.

In summary, the changes which have been suggested here are not large sums of money but mostly administrative and methodological in nature. It is believed that some of these changes would provide solutions to more of the Texas Highway Department's current technical problems than the methods now in practice.

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