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A CHRONICLE
OF THE
KENTUCKY TRANSPORTATION RESEARCH PROGRAM

College of Engineering
University of Kentucky

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EXECUTIVE SUMMARY

The basis for the Kentucky Transportation Research Program (KTRP) was established more than 45 years ago and some of the current staff members have over 35 years experience in transportation research. Over the years, principal investigators have developed expertise in major areas of transportation and have made significant contributions in highway safety, pavement design and performance, embankment analyses, fatigue detection in bridges, noise abatement, traffic control and operations, voidless concrete, pavement texture and skid resistance, structural design and analyses of culverts, traffic forecasting, and numerous other areas.

The Transportation Research Building houses several fully equipped laboratories. Special effort was made to provide flexibility and versatility in the arrangement of fixtures in the various laboratories. Computer services are available through the University of Kentucky and a full-time programming staff capable of summarizing, analyzing, and plotting data is available to all researchers. The Program also maintains a collection of current periodicals and publications from other transportation research organizations.

Appreciable acceptance of study findings and resultant implementation of study recommendations has led to significant benefit-cost ratios for many studies undertaken by the unit. Values derived from research have been demonstrated routinely.

Statistics summarized in the CHRONICLE reflect staff versatility and productivity. In a six-and-a-half-year period (January 1, 1981, through June 30, 1987), KTRP submitted 190 proposals to the Kentucky Transportation Cabinet requesting funding of \$7.1 million. Of those, 180 proposals were funded at \$6.7 million, a 95-percent acceptance rate considering number of proposals and a 95-percent acceptance rate considering funding. Another 166 proposals were submitted to other local, state, and national agencies or organizations requesting an additional \$9.4 million. Of those, 114 proposals were funded at approximately \$2.3 million, a 24-percent acceptance rate for funding. The overall acceptance rate is 83 percent for number of study proposals submitted and 55 percent for funds sought.

During the same six-and-a-half-year period, 195 major reports have been submitted to supporters of research activities, 55 peer-review papers have been published in widely recognized journals and proceedings, and 152 presentations have been made to regional, national, and international professional organizations. Each professional has been responsible, on the average, for over four major reporting items each year.

The Program, in six-and-a-half-years, has expended funds totaling approximately \$9 million. Only in Fiscal Year 1982 was KTRP unsuccessful in obtaining funding sufficient to cover expenditures. In that year, KTRP experienced a \$37,700 shortfall in income. That occurred in face of drastic budgetary cutbacks imposed by various agencies supporting transportation research. The short-fall was minimized through streamlining management practices and more efficient utilization of vehicles, telephones, computing facilities, methods of report reproduction, and copy machines, resulting in annual savings of approximately \$70 to \$80 thousand. Those practices have continued through the years and overall savings have been significant without sacrifice of quality or productivity. KTRP has generated almost \$1.5 million indirect income for the University.

KTRP is the primary research agency for the Kentucky Transportation Cabinet. In addition, KTRP conducts research for the US Army Corps of Engineers, Tennessee Valley Authority, Federal Highway Administration, and municipal and county governmental agencies.

WHAT IS THE KTRP?

The Kentucky Transportation Research Program (KTRP) operates as a non-academic department in the College of Engineering, University of Kentucky. KTRP is devoted to the conduct of a comprehensive research program in the general area of transportation. Research is proposed, conducted, and reported on behalf of the Kentucky Transportation Cabinet and other state, federal, and private agencies requesting research studies. To accomplish this task, the Program has the following objectives:

- To maintain a technical capability and competence to undertake research related to current needs and problems in transportation.
- To plan and conduct research studies relating to the general area of transportation for the Kentucky Transportation Cabinet and other state, federal, and private agencies.
- To disseminate the results of research to the sponsoring agencies and to the general profession.
- To maintain contact with and an awareness of current research activities in transportation around the world.
- To provide an opportunity and support for the involvement of students in transportation research.

KTRP maintains a permanent, full-time professional staff to develop a comprehensive program for the accomplishment of the mission and overall Program objectives. A long-term cooperative agreement has been established with the Kentucky Transportation Cabinet. Other state, local (city and county), federal, and national agencies and the private sector utilize KTRP services. Additionally, KTRP serves as the focal point to assist and facilitate the development of an increased interdisciplinary awareness and involvement in transportation research and related services. KTRP is entrusted with the responsibility of securing and analyzing data and developing facts and information so as to extend the state of knowledge and to further educational opportunities of transportation professionals.

Because of the central position transportation plays in the economy of this country and the world, the necessity for improved technology and management procedures to provide transportation of people and goods is of utmost importance. Research activities are of special significance not only to the agencies that must provide transportation facilities but to the people of this country because of the impact transportation has upon their lives.

HISTORY OF TRANSPORTATION RESEARCH IN KENTUCKY

EARLY HISTORY

With the beginning of federal-aid highway work in Kentucky in the 1910's, the necessity of specifying the quality of materials for road building and the enforcement of specification requirements through testing became increasingly apparent. The Road Materials Testing Laboratory was established in 1914 at the University of Kentucky under Professor D. V. Terrell.

Testing and research were continued jointly under Professor Terrell until 1928; testing services were then transferred to Frankfort where a testing laboratory was provided. Some research, however, continued at the University in the Department of Civil Engineering. Professor Terrell devoted his summers to research, and an attempt was made to utilize the Frankfort forces and facilities during the winter seasons. Those arrangements continued until about 1939 when it became apparent a more intensified and productive research

program was needed. It was realized from previous experience that research was a completely separate entity from testing.

The Kentucky Department of Highways erected a building on the University of Kentucky campus in 1941. Because of the onset of World War II, the facility remained understaffed until 1946. Research was then a branch of the Division of Design. In 1949, it became the Division of Research. In 1967, the Division moved into new quarters.

Since the early 1940's, possibly as many as 1,500 people have come under the supervision of the unit -- either as a student trainee, part-time employee, or full-time staff member. The attrition rate has been rather high inasmuch as a large percentage of staff have been students who departed upon graduation.

RESEARCH IN THE KENTUCKY DEPARTMENT OF HIGHWAYS

The Division of Research was created as an identifiable unit in the Department of Highways (predecessor of the Kentucky Department of Transportation and now, the Kentucky Transportation Cabinet) in the early 1940's when a laboratory facility was constructed on the University of Kentucky campus. A full-time staff of Department of Highway engineers was assigned to conduct research and development activities. Significant numbers of university students were employed as technicians to conduct the laboratory and field work. In 1967, a new (present) facility was completed near the main campus. Major areas of research had included traffic, safety, and operations; pavement mechanics and performance; and materials characterization and behavior.

Nearly 600 major reports were issued during the 40-year life of the Research Division; many of those reports have been published by and presented to numerous regional, national, and international professional associations and organizations. The professional staff of the unit served and participated on committees of the Transportation Research Board, the Institute of Transportation Engineers, the American Society for Testing and Materials, the American Society of Civil Engineers, etc. and on planning committees for regional, national, and international conferences.

CREATION OF THE KTRP

In mid 1980, administrative officials of the then Department of Transportation decided to abolish the Department's Division of Research. Since the Division's facilities were located in the immediate vicinity of the University, initial endeavors were made toward transferring real property and its contents from the Department to the University. The final plan entailed transfer of an intact program, personnel, and facilities from one agency to the other with financial considerations and a contractual agreement. From that, the Kentucky Transportation Research Program was conceived and later emerged.

KTRP was created on January 1, 1981, when the functions, employees, buildings, and equipment of the Division of Research, Kentucky Department of Transportation, were transferred to the University of Kentucky. The research program operates as an entity within the College of Engineering. Studies conducted by KTRP are funded under the auspices of the University of Kentucky Research Foundation and are accounted for in strict conformance with their procedures.

INTERRELATIONSHIPS OF TRANSPORTATION UNITS
AT THE UNIVERSITY OF KENTUCKY

Transportation is an extremely broad subject area impacting upon and receiving input from many professional disciplines. The University of Kentucky, being a large state-supported university, has faculty and staff in a complete range of disciplines that have concerns and interests relating to transportation and transportation research. As a result, transportation research at the University of Kentucky involves disciplines ranging from engineering through agriculture, medicine, human and social relationships, business and economics, education, etc. KTRP maintains a permanent and continuing full-time staff to conduct research and to provide staff support to and to serve as coprincipals with faculty and other staff interested in conducting transportation research. KTRP has over forty-five years of experience in the field. Originally, the efforts were directed toward highway concerns, but in the past two decades increasing effort has been directed towards the general areas of transportation. KTRP also employs undergraduate and graduate students on a part-time basis in an effort to provide those students with practical experience and financial support to enhance their educational programs.

Transportation issues in Kentucky are addressed at the University of Kentucky by means of

1. a comprehensive research and development activity of KTRP and of university faculty,
2. undergraduate and graduate education, primarily within the Department of Civil Engineering but also in other departments of the university,
3. continuing engineering education, and
4. special seminars and symposia sponsored by the Transportation Center and (or) KTRP on behalf of other agencies or groups.

The Transportation Center and KTRP maintain an interest in national issues concerning the transportation industry. Research is proposed, conducted, and reported to not only the Kentucky Transportation Cabinet and other state agencies but to federal, commercial, and private agencies. Proposals have been prepared and submitted addressing such national concerns as transportation systems management, stopping sight distance, traffic conflicts and accidents, highway shoulder design, evaluation of pavement properties, speed zoning and control, gore area accidents, etc.

The Transportation Center and KTRP share the same building. Also, the transportation engineering faculty of the Department of Civil Engineering has offices in the research building, as does the Office of Engineering Continuing Education. A close physical proximity of the various units interested in transportation research and education lead to a beneficial relationship between KTRP staff, University faculty (particularly engineering faculty), and the Transportation Center staff. Transportation courses (undergraduate and graduate) are taught in the building by the Civil Engineering faculty. Additionally, some staff members of KTRP also teach at the undergraduate and graduate levels in the College of Engineering. At times, Civil Engineering faculty serve as coprincipal investigators for Research Program studies. The Civil Engineering faculty and the staff of KTRP are involved with the Office of Continuing Education and Extension and the Transportation Center in developing information and improved skills and to transfer technology developed as a result of research activities.

AREAS OF EXPERTISE AND ACTIVITIES

Primary research capabilities and selected activities of KTRP include the following:

- . Traffic Safety and Operation
 - Capacity of Signalized Intersections
 - Roadway Delineation Techniques
 - Warrants for Left-Turn Lanes and Signal Phasing
 - Characteristics of High-Risk Drivers
 - Rumble Strip Design and Usage
 - Effectiveness of Transportation Services
 - Problem Identification for Highway Safety Plan
 - Impact of Traffic Alcohol Programs
 - Accident Reconstruction
 - Traffic Control in Work Zones
- . Pavement Mechanics and Performance
 - Full-depth Asphaltic Concrete Pavements
 - Flexible Pavement Rutting Behavior
 - Analyses of Portland Cement Concrete Pavements
 - Strain Energy Principles Applied to Asphaltic Concrete Design
 - Pavement Performance
 - Pavement Serviceability Studies
 - Designs for Layers Using Waste Products
 - Road Rater and Falling Weight Deflectometer Testing
- . Materials Characterization and Behavior
 - Slope Stability Analysis
 - Properties of Kentucky Shales
 - Earthquake Forces
 - Masonary Coatings
 - Stability of Asphaltic Mixtures
 - Reflex-Reflective Materials
- . Structures
 - Loads on Box Culverts under High Embankments
 - Soil-bridge Abutment Interaction
 - Acoustic Emission Monitoring
 - Computerized Bridge Management
 - Embankments with Tensile Elements
- . Economics
 - Assignment of Transportation Costs to Users
 - Life-Cycle Costing of Pavements

HIGHWAY SAFETY

Significant interest in this subject area has been the basis for numerous studies. The effects of safety improvements and specific highway features have been investigated. Those features include items such as crash cushions, rumble strips, guardrails, and guardrail end treatments. Some features were experimental and others were standards that had not previously been evaluated. Accident analyses have been another major research priority. Analyses of specific time periods, such as those related to the energy crisis of 1974, daytime versus nighttime, and weekdays, weekends, and holidays, have resulted in identification of time periods that may warrant special attention and increased enforcement. Studies to determine the effects of vehicle characteristics on highway safety have been undertaken. Primary emphasis was

focused on the aspect of relating vehicle make and model to accidents. The relationship between size of vehicle and accidents also was investigated.

ROADWAY DELINEATION

Previous research has shown that accident rates are significantly less during daylight hours as compared to hours during darkness. Also, the accident rate on wet pavements was approximately twice that on dry pavements. With those statistics in hand, it is easy to see why rainy, nighttime visibility has been a research priority. Attempts have been made to improve roadway delineation by providing better embedment and adhesion of glass beads in paint stripes. Previously reported results have identified problems associated with paint striping, and solutions appear to be within reach.

Another area that received considerable attention was the testing and evaluation of raised pavement markers. That type of delineation is certainly efficient during rainy, nighttime conditions; however, the need for snowplowing resulted in significant damage and diminished their usefulness. In an attempt to determine the best snowplowable pavement marker, four types were installed for evaluation; other types have been evaluated since. Raised markers also have been evaluated for use at lane drops and high-hazard locations. Along with other types of delineation, raised markers have been tested to determine the best type of delineation at stop-sign approaches.

Pavement tapes and thermoplastic striping have been suggested as alternatives to regular paint striping. Prior work has shown that neither is economically justifiable for widescale usage. Presently, several types of pavement tapes are being evaluated, primarily for use on very high-volume highways or in construction and work zones.

TRANSPORTATION ECONOMICS

Even though most transportation research must take economics into consideration, several studies have dealt with economics as a primary emphasis. Many studies have included accident analyses as the major justification of a safety improvement; however, there have been more purely economic studies. Those were socio-economic studies that evaluated the impact of developmental highways on the economic growth of the surrounding region. The allocation of costs of highway facilities to various classes of users has been investigated. Involved in that study were interrelationships of highway revenues generated through registration fees and fuel taxes, facilities required by each vehicle class, and damage done by each vehicle class. Economic studies have been undertaken to devise fair and reasonable methods of taxing highway users so all pay a fair share.

Most closely aligned with highway safety, an economic analysis of access control on bypasses was made to determine when to build an interchange as opposed to an at-grade intersection. Other economic analyses related to accidents have emphasized dynamic programming as a method to prioritize highway safety improvements. Also, dynamic programming was used as the method to obtain the optimum arrangement of projects, based on benefits and costs, for comprehensive safety improvement programs for Kentucky's interstate and toll road systems. A similar safety improvement program for the primary system also was developed.

A relative new area related to economics now under study is life-cycle costing for pavements. Efforts are being made to determine the most cost effective designs for pavement construction, reconstruction, or rehabilitation.

TRAFFIC NOISE

Work in the area of traffic noise has been concerned primarily with evaluations of the methods used to predict traffic noise and adjustments needed in the prediction procedure. The procedure originally used in Kentucky to predict traffic noise was outlined in NCHRP Report 117. An evaluation of that procedure resulted in a correction nomograph that was used for several years. Recently, an evaluation of the Federal Highway Administration prediction procedure was done, and the recommendation was made that this procedure be adopted.

Studies concerning possible adjustments to the prediction procedures have been performed. Adjustments for different pavement textures were recommended. The effect of interrupted flow on traffic noise was investigated. Surveys of individual vehicle noise have been done for use as input into the prediction procedures.

Another area that has been investigated concerns the propagation of traffic noise. The effects of various traffic, ground cover, and geometric conditions on traffic noise propagation were evaluated. More recently, the effectiveness of a noise barrier was studied.

TRAFFIC CONTROL AND OPERATIONS

The efficient control of traffic flow has been another general area of research. Several studies have dealt with left turns at intersections. A survey of use of left-turn-on-red was done when a law permitting that movement was being considered by the Kentucky legislature. Warrants were developed for left-turn phasing and left-turn lanes. An evaluation of permissive left-turn phasing also was done. Another type of traffic control evaluated was reversible lanes. A "before and after" evaluation of a reversible lane system installed in Lexington was done.

A study of signal timing optimization was undertaken to evaluate the effectiveness of the TRANSIT 7 and SIGOP 2 signal timing optimization programs as a method of optimizing signal time plans in a 62-signal network in the central business district of Lexington.

The use of traffic conflicts also has been studied. A method of collecting traffic conflict data was developed. Relationships between traffic conflicts and accidents at intersections were studied with the objective of identifying intersections having high-accident potentials.

Another study involved the capacity of signalized intersections. The objectives were to determine the actual capacity of signalized intersections, analyze the factors affecting capacity, compare field measurements with calculated capacities, and determine how actual intersection capacities vary for different locations across a state.

Signing and/or signalization at rural, high-speed intersections have been studied. Data analysis revealed safe and unsafe treatments and recommendations were presented for correction of unsafe intersections. Traffic control studies for maintenance and construction work zones identified problem areas and presented solutions.

TRAFFIC FORECASTING

Traffic forecasting with computerized models has produced some very practical results during the past few years. Origin-destination studies at 170 outdoor recreational areas in Kentucky produced a data base used to develop models to predict the number of trips attracted to a recreational area. Additional work in that area involved preparation of a historical file of traffic volume data at ten recreational areas. The purpose was to provide sufficient data for planning and design of highways with heavy volumes of

recreational travel.

Models to predict internal-external and through trips for small urban areas were developed from existing data representing 20 cities in Kentucky. The models proved to be sufficiently accurate for planning purposes, considering the types of trips to be predicted.

Another study used the interrelationships of traffic on rural multilane highways to develop models for predicting lane distributions and percentages of various vehicle types. The equations for predicting lane distributions were revisions of equations that were outdated because of the significant increase in percentages of trucks. The development and testing of the most accurate and practical method for determination of the number of lanes for highways have been under study. Traditionally, this decision has been made utilizing the design-hour volume of the design year; however, some criticism has arisen concerning that method and further research is needed to clarify its validity.

Several studies have investigated axle weights for various vehicles in efforts to determine the expected equivalent axleloads for pavement thickness designs and life expectancies. Efforts are being made to evaluate weigh-in-motion systems to obtain an expanded data base of axle weights.

DRIVER CHARACTERISTICS

Another general area of research has involved driver characteristics. Driver error is responsible for the majority of all traffic accidents. Characteristics of the driver population in Kentucky has been examined and related to driving records and traffic accidents. Also, the characteristics of high-risk drivers have been compared to the total driving population. Statistics such as accident rates of males compared to females and the change in accident rate as a function of age have been determined.

Seatbelt usage in Kentucky has been the focus of some research. The effectiveness and usage of seatbelts by drivers and passengers have been investigated. Field observation, accident reports, and questionnaires have been used as the data base. Utilization rates and effectiveness of child restraint devices have been studied.

Methods used to identify high-risk drivers have been examined. Kentucky's point system was analyzed based on a comparison with point systems used in other states and an analysis of driving records. Revisions to the point system were recommended. The effectiveness of driver-improvement clinics also has been studied.

Traffic alcohol programs have been implemented in recent years and studies have been undertaken to evaluate the effectiveness of those programs. The programs were judged successful as well as self supporting.

PROBLEM IDENTIFICATION

To comply with federal regulations, each state is required to prepare an annual highway safety plan. Kentucky's program, which includes identification, programming, budgeting, and evaluation of highway safety projects, is intended to have a positive impact on the reduction of traffic accidents. The first step of the program, problem identification, requires systematic statistical analyses of accident records. In-depth analyses were performed and problem areas were investigated. Reports on problem identification have been prepared for the Kentucky Office of Highway Safety Programs and the Kentucky State Police.

TRANSPORTATION SERVICES

With new emphasis on public accountability and program evaluation, the need for effective measures to indicate the extent to which an agency's goals and objectives are being met is apparent. It is necessary to assemble current data and to generate other information in such a form that policy makers may determine whether transportation systems and services are improving or deteriorating. The appropriateness of certain measures and the methods of data presentation were investigated.

The first phase of the study to evaluate transportation services was to conduct a public opinion survey of licensed drivers and public transit riders. Questionnaires were mailed to 10,000 licensed drivers and distributed to 4,500 transit riders. Results of the surveys were summarized. The second phase of the ongoing study involved collection of other types of data for evaluation of transportation services. Travel times and delay measures, roughness data, safety and accident statistics, environmental impacts, traffic volumes, identification of hazardous locations, and economic impacts were studied and reported.

MATERIALS CHARACTERISTICS

KTRP has several decades of experience in defining and quantifying the engineering parameters of many materials used in the construction of transportation facilities. In addition, considerable experience has been gained in field instrumentation for measuring the interaction of related elements of engineering systems.

Capability exists for testing the shear strength of granular materials using the isotropically confined triaxial compression test or using the direct shear test. Also, the compressibility of those materials may be tested using the conventional consolidation test or using such state-of-the-art methods as controlled-gradient or constant-rate-of-strain tests.

Equipment, technology, and experience for performing rheological studies on various materials are also available. This includes stress relaxation tests and creep tests. Those data may be converted from the time domain to the frequency domain to determine frequency distributions, phase angles, and hysteresis properties of those materials. Most of those properties were defined from repeated-load and resonant column tests.

Appreciable work has been done in the field to define the magnitude, shape, location, type, and rate of movements in flexible pavements and earth structures. Personnel of KTRP have designed, developed, fabricated, or improved many instruments necessary to record field data. Expertise is available for measuring and analyzing earth pressures on buried structures.

Full-scale analyses have been performed on highway landslides and bridge approaches. Those studies included extensive soil and geological analyses, monitoring and analysis of ground-water flow, and slope stability analyses. In most cases, remedial designs have been proposed and implemented.

ANALYSES OF PAVEMENT PERFORMANCE

Pavement performance may be defined in a number of ways. In the past, surface deflections, pavement roughness, rutting, and accumulated traffic have been used to evaluate pavement performance. A subjective rating system (Present Serviceability Index) has been used as a measure of pavement performance. Pavement roughness, rutting, and cracking have been related to the Present Serviceability Index. Pavement management systems have been developed and implemented for jurisdictions with both small and large mileages of highways and streets. Such systems provide administrators a tool to assist

in programming, budgeting, and scheduling maintenance and rehabilitation activities to maximize benefits to the taxpayer.

DYNAMIC TESTS OF PAVEMENTS

The behavior of pavements has been the subject of extensive investigations for over 40 years. A major break-through has been the development of a nondestructive tester that vibrates the pavement, measures those vibrations, and expresses them as deflections. A companion break-through has been the matching of those measured deflections with elastic theory. The behavior of the pavement may be evaluated in terms of thickness of material of reference quality. This evaluation determines the effectiveness of the existing pavement, an essential ingredient in determining the proper overlay thickness. The evaluation also provides an estimate of the in-place subgrade strength at the test site. Combining test results permits determination of the design strength of the subgrade.

FATIGUE DAMAGE TO PAVEMENTS

The load, number of tires, tire pressures, and axles in a given grouping and distribution of load within that grouping have been subjects of extensive investigations during the past several years. The investigations included analyses of pavement thicknesses used at the AASHO Road Test, which has been accepted internationally as one of the better field studies of pavement behavior. An important outcome has been the development of damage factors for single- and tandem-axle arrangements developed from the AASHO Road Test. The damage caused by the steering axle was included as an undefined portion of the damage caused by other axles. Separating the damage caused by the steering axle permitted development of damage factors for groups of axles and tires not investigated at the AASHO Road Test, but which are being used on highways today. Furthermore, the investigation has shown that the calculated damage is almost identical using either set of damage factors. With the increased use of wide tires, increasing loads on the steering axle, and increases in tire pressures, the use of the newer set of damage factors becomes essential.

A study of truck axleloads has revealed that only 10 percent of the tandem axle arrangements have the load distributed equally between the two axles of that group. AASHTO damage factors are based upon the load being distributed equally. Adjustment factors were developed to account for the increased damage caused by uneven loading between the two axles. The uneven loading accounts for a minimum of 25 percent increase in fatigue damage that would not be accounted for using AASHTO damage factors.

PAVEMENT RUTTING

When the pavement structure is relatively thin, subsequent rutting may be attributable to shear failure in the subgrade. Rutting that develops in thick asphaltic pavements may be the result of severe tire loads (pressures) that cause lateral movement within the top six inches due to instability of the asphaltic mixture. A second major cause is consolidation (compaction) due to traffic. Traffic will complete the compaction of the asphaltic concrete not achieved during construction and will be manifested as rutting. Rutting has been correlated with fatigue of the pavement and design procedures were developed to minimize rutting potential in asphaltic concrete pavement systems.

TRAFFIC ANALYSES

Procedures have been developed to estimate the volumes of traffic and the percentages of each vehicle classification of the total volume and by each

lane. Combining the volume of traffic and appropriate damage factors for each vehicle classification with the number of years desired for future projections yields the design fatigue life.

OVERLAY DESIGN

A system has been developed to design an overlay thickness that incorporates the design fatigue life for the anticipated future traffic and the structural capacity of the existing pavement. Economics may be used to determine which overlay designs may be feasible and appropriate to a given condition.

CONSTRUCTION AND REHABILITATION

KTRP is concerned with developing a methodology to optimize maintenance and rehabilitation procedures for pavements and bridges while developing new technology in the construction of pavements and bridges. Maintenance of the transportation system is an ever-increasing problem facing transportation engineers. Optimization of maintenance procedures, through the implementation of new products and/or techniques, might help relieve fiscal crises now facing governmental agencies. Conservation of materials and energy may be realized through recycling of pavements while providing a savings of tax dollars. Implementation of new geometric design principles and/or use of new construction techniques and/or products to improve service life of transportation facilities will be of further benefit.

GEOTECHNOLOGY

Expertise is available through KTRP to perform the following tasks:

1. Assess and evaluate conventional geotechnical design, construction, or maintenance methods used in transportation engineering.
2. Assess and evaluate experimental design, construction, or maintenance procedures.
3. Develop and maintain geotechnical engineering or engineering geology data files to be used as design and research tools.

Current efforts are being directed toward providing a basis for development of a generalized overview of Kentucky soils. KTRP and Transportation Cabinet data banks will be merged and a computer program will be developed to examine those data.

SPECIFICATION TESTING

Because of its personnel and specialized equipment, KTRP is uniquely qualified to conduct specification and qualifying tests on certain materials.

IMPROMPTU INVESTIGATIONS

KTRP investigators frequently are asked to conduct impromptu investigations for the evaluation of the performance of materials, construction procedures, analyses of failures, and other related features of highway design, construction, and maintenance. Those investigations vary in complexity and nature, depending upon the situation and information desired. Most often, the investigations serve as a means of providing a tentative solution or analysis of immediate problems. In some cases, a full-scale project may result from what initially began as a minor investigation. These impromptu investigations serve a vital function through provision of an immediate report on a particular problem.

As technology advances and industry expands, there is an increasing number of new products that become available for potential use in highway construction or maintenance. Some of those products may be used under current

specifications or special provisions. Others may not be covered, and it is essential that such products be evaluated prior to widespread use.

COMPUTER SERVICES

Data collection and analysis is an integral part of the transportation research function. Historical data have proven valuable. Unfortunately, data are often assembled for a specific purpose, forgotten, and the file not periodically updated. Months or years later an investigation requiring the same or similar data is undertaken, and the data file must be reassembled. For those reasons, KTRP maintains, updating when appropriate, long-term data files such as highway accidents, traffic classifications, truck weights, state mileage information, traffic volume, and information related to soils and rock characteristics.

In addition, KTRP has a programming staff capable of summarizing, analyzing, and plotting data. Available software includes scientific, statistical, plotting, and data management and retrieval packages. Both mainframe and personal computers are utilized extensively.

FACILITIES AND EQUIPMENT

Achievement of KTRP goals is significantly enhanced through provision of modern, well-equipped facilities. An up-to-date library coupled with extensive project files and a computerized information retrieval system provides information access for faculty, staff, and students. The facilities house a variety of equipment and instrumentation necessary for both field and laboratory studies. Longevity of several staff members provides a valuable source of expertise within numerous areas of the transportation field.

FACILITIES AND EQUIPMENT OF KTRP

KTRP is housed in a large laboratory and office building on the University of Kentucky's main campus. The facility is designed to provide adequate accommodations for both personnel and equipment.

The present facilities were designed and constructed in 1966-67 at a cost of approximately 600 thousand dollars. The 200- x 100-foot site was selected as part of the University of Kentucky's developmental and land use plan. The building contains 22,700 square feet. A special effort was made to provide flexibility and versatility in the arrangement of fixtures in the various laboratories. Most utilities, hot and cold water, natural gas, compressed air, vacuum, and electrical service (110 volts and 220 volts), are exposed in each of the laboratories. Numerous cutoff valves and switch boxes are provided so that utility connections may be made conveniently when required for new instrumentation or test equipment. All laboratory furnishings are movable, and the arrangement of the various laboratories and work areas may be changed easily when the need arises.

A 3,100-square foot garage is used for housing and servicing special test vehicles, as a storage area that serves as a depository for material samples and miscellaneous items, and a work area for sample preparation of soils, aggregate, and other materials. The structure is designed for a second level addition or rooftop parking. The remainder of the site is a fenced parking lot for university-owned vehicles.

In addition to the physical plant, the research facility has a variety of equipment and instrumentation necessary for routine tests and evaluations of materials and special equipment and instrumentation for research. The list of unusual or significant equipment includes items such as an automatic freeze-

thaw box, strain-controlled and stress-controlled triaxial testing machines, consolidation testing equipment, a Road Rater and falling weight deflectometer used in testing structural characteristics of pavements, a noise level meter and recorder, acoustic emission instrumentation, an analog data-reduction system, a colorimeter, a vacuum auger extrusion machine for preparing soil specimens, a cone penetrometer, and a vane shear-apparatus. Accessory equipment such as an infrared thermometer, water baths, digital voltmeters, amplifiers, transducers, voltage and current reference sources, strip-chart and magnetic tape recorders, oscillographs, oscilloscopes, accelerometers, ovens, aggregate processing equipment, testing machines, and desk calculators is available. A programmable testing machine is to be obtained soon.

OTHER SERVICES

Electronic data processing is an increasingly valuable tool in many research studies undertaken by the Kentucky Transportation Research Program. Computer facilities are provided by the University of Kentucky Computing Center. An IBM 3081 computer at the University of Kentucky is available. An IBM 3090 system supercomputer is to be installed soon. Magnetic tapes and disc storage are available for program and data storage and manipulation. Numerical and statistical software packages as well as plotters are available for use.

Through the Office of Engineering Services within the College of Engineering, KTRP has access to personnel and equipment to provide expert services in areas such as carpentry, painting, electrical, mechanical, sheet metal, casting, and machine shops, and typing and graphic arts services.

LIBRARIES

The University of Kentucky Library, among the top fifty research libraries in the country, has a strong transportation collection. Holdings include approximately 400 serials and journals, 200 reference books, and several thousand monographs. The Geology Library and the main library Map Department contain numerous maps of interest to individuals studying transportation or transportation-related topics. In addition, current news and many early works relating to transportation are available in the main library's Periodicals/Newspapers/Microtexts Department.

Resources not available within the library's collection may be obtained from other institutions through the Interlibrary Loan Department. Another service provided by both the main library and the Engineering Library is on-line literature searching. Available data bases covering transportation and peripheral areas include Tris-on-Line, NTIS, Compendix, and Pollution Abstracts. In addition, the expertise of professional librarians is available upon request.

The library and its resources are available to all serious scholars for on-site use, and special borrowing privileges are extended to all citizens of Kentucky.

LABORATORIES

In addition to its own facilities, KTRP has access to the laboratories of the Civil Engineering Department. Specialized laboratory facilities and personnel are available for doing biological studies through the Wenner-Gren Research Laboratory.

Geotechnical Engineering

The Geotechnical Engineering Laboratory is located in the D. V. Terrell Building. The laboratory is well equipped for all conventional soil mechanics

special testing equipment has been developed at this facility, some of which is in use throughout the world. To aid in teaching and research, the laboratory has a computer-controlled data acquisition system, a closed-circuit television system, and computer terminals connected to the University's IBM 3081 computer and Prime computing systems.

Rock Mechanics

The Rock Mechanics Laboratory has facilities for wet and dry cutting, surface grinding of rock specimens, and static testing to determine physical properties. Large laboratory polyaxial equipment for limited loading on 380-mm cubes of rock is available. Conventional laboratories for coal preparation instruction and research are complemented by petrographic facilities and x-ray diffraction equipment.

The rock mechanics section is currently involved in underground and surface field investigations and has permissible drilling and auxiliary equipment for placement of various types of stress-change monitoring transducers and determination of absolute stresses by the overcoring technique.

Fluid Mechanics

The Fluid Mechanics and Hydraulics Laboratory is equipped for undergraduate teaching and graduate research needs. Specific facilities include a 75-foot-long x 2-foot x 2-foot cross-sectional glass flume composed of three sections, which may be adjusted separately by electric motors to different slopes for flow profile analysis. A specifically designed rainfall simulator is also available. The laboratory is equipped with transient flow and solid-liquid flow facilities.

Structural Engineering

Testing of full-scale structural models is carried out in the Structural Engineering Research Laboratory complete with heavy-duty loading floor, cranes, and access galleries below the floor. The laboratory has special provisions for the maintenance of constant temperature and humidity. Equipment available includes a heavy-duty pumping and indicating unit with a hydraulic capacity of one gallon per minute at 10,000 psi and load holder and preload devices. Also available is a transducer output recording unit that has the capability of reading up to 70 channels of data sequentially and automatically. Additional equipment includes jacks in various sizes up to 100 tons, miscellaneous load cells, hand and power tools, etc.

Materials Testing

A well-equipped materials testing laboratory is available for evaluating various types of building materials, including those used in the construction of transportation facilities. The laboratory comprises facilities for designing concrete and bituminous mixes and equipment for determining quality aspects, such as strength and durability, of mineral aggregates, portland cement concrete, bituminous mixes, structural steel, and other materials used in construction applications. A 300,000-pound capacity universal strength testing machine, a 400,000-pound compression testing machine, smaller capacity testing machines, and other appurtenant equipment are available. Through the computer-controlled data acquisition system, most test results may be recorded and analyzed automatically.

Surveying and Photogrammetry

All types of surveying instrumentation, including optical transits and

optical reading theodolites up to first-order (Wild T-3), self-leveling and tilting levels (one with optical micrometer), and a Wild DI-10 Electronic Distance Meter are available in the surveying laboratory.

A photogrammetry lab including Kelsh and Multipler Stereoplotters, dual-viewing mirror stereoscope DBA Multilaterative Comparator, and a B & L Zoom Transfer Scope is available.

Water Quality Control

The Water Quality Control Laboratory is equipped to perform conventional water quality analyses. Equipment includes atomic absorption apparatus carbon analyzer; carbon-hydrogen-nitrogen analyzer; visible, ultraviolet, and infrared spectrophotometers; refrigerated centrifuge; liquid scintillation counter; fluorometer; electrolysis BOD apparatus; respirometers; and specific ion, dissolved oxygen, and pH meters. Constant temperature rooms and other facilities for laboratory-scale process evaluations are available. Equipment available for field work includes portable composite samplers, fluorometers, pumps, magnetic current meter, and dissolved oxygen meters.

RESEARCH STAFF

ROBERT C. DEEN, PE, LS; Director

Robert C. Deen, BSCE, MSCE, PhD (Civil Engineering), JD, has been actively involved in transportation research since 1955. From 1963 to 1981 he served as Assistant Director of Research for the Kentucky Department of Transportation. Since 1960, Dr. Deen has served as a lecturer and associate professor of Civil Engineering at the University of Kentucky, teaching both undergraduate and graduate courses. He has developed and served as instructor for numerous short courses, seminars, and workshops in various areas including soil mechanics, slope stability, core drilling, and value engineering. Dr. Deen's service as an officer of professional organizations has been recognized by distinguished service citations and honorary memberships. He has published over ninety technical papers and reports, many of which have received national recognition. Areas of professional interest include geotechnical engineering; pavement design, performance, and evaluation; and traffic safety and operations.

RONALD D. HUGHES, PE; Deputy Director

R. D. Hughes, BSCE, MSCE, has 34 years of experience in transportation research. His areas of research interests include structural and hydraulic design of pipe and box culverts, durability of reinforced concrete bridge decks and related materials, and development of materials and construction specifications.

KENNETH R. AGENT, PE; Chief Research Engineer

Kenneth R. Agent holds Bachelor of Science and Master of Science in Civil Engineering degrees from the University of Kentucky. Past research efforts have been in the general area of traffic and safety. Primarily, the studies have involved an evaluation of various traffic control devices and traffic operations, analysis of accident records, programming improvements and economic analyses, driver characteristics studies, and traffic noise studies.

DAVID L. ALLEN, PE; Chief Research Engineer

David Allen, BSCE, became involved in transportation research in 1970 after graduating from the University of Kentucky College of Engineering. Much

after graduating from the University of Kentucky College of Engineering. Much of his efforts have been directed to the study of the engineering properties of materials. Part of his efforts includes in-depth analyses of soil properties and the stability of earth structures. He has done extensive work to determine the rheological properties of asphalts and base course materials used in flexible pavements. Also, he has studied the behavior of soil-structure systems, including such structures as bridge abutments and buried conduits. David is a licensed Civil Engineer and is a member of the Kentucky Society of Professional Engineers and the American Society of Civil Engineers.

MARK ANDERSON, PE; Senior Research Engineer

Mark Anderson, BSCE, MSCE, is doing graduate work in pursuit of a PhD degree. Mr. Anderson is principally involved in work related to geotechnical engineering, materials, evaluation, and nondestructive testing of materials and pavements. Mr. Anderson has worked in the transportation area since obtaining his MSCE degree in 1981.

JOSEPH D. CRABTREE, PE; Transportation Research Engineer

Mr. Crabtree, BSCE, MSCE, has been a research engineer for KTRP since September 1979. He has been directly involved with studies relating to highway safety improvements, problem identification, effectiveness of transportation services, capacity of signalized intersections, determining number of lanes for highways, and effects of vehicle characteristics on highway safety. Mr. Crabtree has been on military leave since February 1983 and will return on September 28, 1987.

SCOTT P. HALL, EIT; Research Engineer

Scott P. Hall, BSCE, MSCE, has been active primarily in pavement condition evaluations and rehabilitation strategies. Other areas of professional interest include highway construction materials, drainage characteristics, and hydraulics.

TOMMY C. HOPKINS, PE; Chief Research Engineer

Tommy C. Hopkins, MSCE and BSCE, has been engaged in research in soil mechanics. His research interests include slope stability analysis, settlement analysis of earth structures, shale properties and uses, geotechnical field instrumentation development, and landslide investigations. He has served as part-time instructor at the University of Kentucky and has taught a short course in soil mechanics through Continuing Education. He has served on planning committees for the Ohio River Valley Soils Seminar (ORVSS) and the Kentucky Society of Professional Engineers (state meeting).

THEODORE HOPWOOD II, PE; Chief Research Engineer

Theodore Hopwood II holds a bachelor of science degree in mechanical engineering (1972) and a master's degree in metallurgy (1975). Mr. Hopwood is engaged in work related to the structural integrity of steel bridges. His areas of work include failure analysis, corrosion prevention, welding, and nondestructive evaluation.

DAVID Q. HUNSUCKER, EIT; Research Engineer Associate

David Quentin Hunsucker holds a bachelor of science degree in Civil Engineering (1983) from the University of Kentucky. His research activities have been primarily in materials testing and evaluation, including freeze-and-thaw testing and strength determinations of pavement materials, pavement rehabilitation and performance, and the development of methods for utilization

of coal waste materials for highway construction.

BOBBY W. MEADE, LS; Transportation Research Investigator

Bobby Meade has a associate degree in applied science (CE) from the University of Kentucky Community College System (1972). Mr. Meade's work has generally involved experimental highway materials and structures.

JERRY G. PIGMAN, PE; Chief Research Engineer

Jerry G. Pigman has BS and MS degrees in Civil Engineering from the University of Kentucky. As a research engineer, his responsibilities have included the supervision of other civil engineers and engineering aides in the collection and analysis, evaluation, and reporting of data related to transportation research. Research studies and operational analyses with which he has been involved include a wide range of activities in the areas of transportation safety, planning, and economic analysis. Specific areas of research include highway safety, roadway delineation, transportation economics, traffic control and operations, traffic forecasting, and safety problems. Presently, he is serving on technical committees of the Transportation Research Board and the Institute of Transportation Engineers.

GARY W. SHARPE, PE, LS; Chief Research Engineer

Gary Wayne Sharpe, MSCE, has been involved in transportation since 1976. Mr. Sharpe's research activities have been primarily in pavement testing, evaluation, and design. He also has been involved in research in pavement rehabilitation, performance, management, and various applications of statistical and computer simulation techniques for use in the development of evaluation and design procedures. Additional areas of professional interest involve material characteristics, geometric design of highways, and traffic flow and operations.

HERBERT F. SOUTHGATE, PE; Chief Research Engineer

Herbert F. Southgate received a BSCE from Virginia Military Institute (1955) and a MSCE from the University of Kentucky (1968), specializing in soils and highways. He has been involved in developing thickness design procedures for highway concrete pavements, a system to evaluate the condition of existing pavements using a vibratory tester, and evaluation of fatigue caused by various wheel configurations on vehicles. He was appointed a consultant to the Governor's Task Force on Coal Haul Problems, and is a member of Transportation Research Board Committee on Pavement Evaluation.

NEIL W. TOLLNER, System Analyst/Programmer

Neil Tollner has served as engineering support staff since September 1973. He supervises the Technical Support Staff and data file management. His duties include writing programs and assisting engineers in updating or rewriting existing programs. He also investigates new features and procedures of existing or new software and devises methods to use them, if applicable. He is responsible for writing and maintaining several data acquisition and control programs used in the laboratory. He assists other members of the KTRP staff with problems, special requests, and implementing new software or features.

MEASURES OF PRODUCTIVITY

PROPOSAL SUBMISSIONS

FISCAL YEAR AND SOURCE	PROPOSALS SUBMITTED		PROPOSALS FUNDED		PERCENT ACCEPTANCE	
	NUMBER	AMOUNT	NUMBER	AMOUNT	NUMBER	AMOUNT
1981						
KTC	61	\$ 661,700	61	\$ 661,700	100	100
Others	16	3,669,387	1	36,597	6	1
Total	77	4,331,087	62	698,297	81	16
Per Person-Year						
All Personnel	4.1	231,609	3.3	37,342		
Professionals	9.6	541,386	7.8	87,287		
1982						
KTC	17	745,670	17	745,670	100	100
Others	29	1,457,100	19	245,477	66	17
Total	46	2,202,770	36	991,147	63	44
Per Person-Year						
All Personnel	1.4	64,978	1.1	29,237		
Professionals	3.1	148,836	2.4	66,969		
1983						
KTC	23	1,101,700	16	765,900	70	70
Others	22	1,230,696	12	193,771	55	16
Total	45	2,332,396	28	959,671	62	41
Per Person-Year						
All Personnel	1.7	89,022	1.1	37,634		
Professionals	3.7	192,760	2.4	82,730		
1984						
KTC	23	1,047,900	23	1,047,900	100	100
Others	20	1,160,695	13	326,646	65	28
Total	43	2,208,595	36	1,374,546	84	62
Per Person-Year						
All Personnel	1.4	71,476	1.2	44,484		
Professionals	3.2	164,820	2.7	102,578		
1985						
KTC	24	1,097,100	21	1,063,200	88	97
Others	17	453,658	15	339,530	88	75
Total	41	1,550,758	36	1,402,730	88	90
Per Person-Year						
All Personnel	1.3	50,678	1.2	45,841		
Professionals	2.8	106,216	2.5	96,077		
1986						
KTC	21	1,204,050	21	1,204,050	100	100
Others	33	669,841	27	462,562	82	69
Total	54	1,873,891	48	1,666,612	89	89
Per Person-Year						
All Personnel	1.9	64,395	1.6	57,272		
Professionals	3.9	136,780	3.5	121,650		

PROPOSAL SUBMISSIONS

FISCAL YEAR AND SOURCE	PROPOSALS SUBMITTED		PROPOSALS FUNDED		PERCENT ACCEPTANCE	
	NUMBER	AMOUNT	NUMBER	AMOUNT	NUMBER	AMOUNT
1987						
KTC	21	\$ 1,204,050	21	\$ 1,204,050	100	100
Others	29	767,611	27	693,611	93	90
Total	50	1,971,661	48	1,897,661	94	96
Per Person-Year						
All Personnel	1.8	68,939	1.7	66,352		
Professionals	3.8	144,975	3.5	139,534		

MAJOR REPORTS ISSUED, PEER REVIEW PAPERS, AND PRESENTATIONS

FISCAL YEAR	MAJOR REPORTS		PEER REVIEW PAPERS		PRESENTATIONS	
	NUMBER	AUTHORS	NUMBER	AUTHORS	NUMBER	PRESENTERS
1981	24	49	11	19	8	13
Per Person-Year						
All Personnel	1.28		0.59		0.43	
Professionals	3.00		1.38		1.00	
1982	18	40	7	14	19	23
Per Person-Year						
All Personnel	0.53		0.21		0.56	
Professionals	1.22		0.47		1.28	
1983	28	66	8	19	30	52
Per Person-Year						
All Personnel	1.07		0.31		1.15	
Professionals	2.31		0.66		2.48	
1984	36	78	7	18	14	26
Per Person-Year						
All Personnel	1.17		0.23		0.47	
Professionals	2.69		0.52		1.04	
1985	31	73	9	20	37	51
Per Person-Year						
All Personnel	1.01		0.29		1.21	
Professionals	2.12		0.62		2.53	
1986	31	59	7	14	20	28
Per Person-Year						
All Personnel	1.07		0.24		0.69	
Professionals	2.26		0.51		1.46	
1987	27	56	6	13	24	31
Per Person-Year						
All Personnel	0.94		0.21		0.84	
Professionals	1.99		0.44		1.76	

PERSONNEL SUMMARY

FISCAL YEAR	PROFESSIONAL STAFF		SUPPORT STAFF		TOTAL STAFF		STUDENTS(NUMBER)	
	NUMBER	PERSON- YEARS	NUMBER	PERSON- YEARS	NUMBER	PERSON- YEARS	UNDER- GRADUATE	GRADUATE
1981*	16	8.0	27	11.0	43	19.0		
1982	16	14.8	24	19.1	40	33.9		
1983	13	12.1	20	14.4	33	26.5		
1984	14	13.4	20	17.5	34	30.9	15	4
1985	15	14.6	26	16.0	41	30.6	13	2
1986	14	13.7	18	15.4	32	29.1	14	2
1987	15	13.6	17	15.0	32	28.6	15	9

* Represents one-half of the fiscal year

STAFF REGISTER

Revised July 1987

NAME	POSITION	BEGINNING DATE	ENDING DATE	
B. P. Adams	Transportation Research Engineer	5-18-87		
K. R. Agent	Senior Research Engineer	1-1-81		
D. L. Allen	Chief Research Engineer	1-1-81		
M. Anderson	Transportation Research Engineer	3-22-83		
W. V. Azevedo	Principal Research Engineer	1-1-81	4-14-82	Resigned
T. L. Beckham	Engineering Technologist II	1-1-81	11-12-82	Resigned
		4-9-84		
J. E. Black	Senior Research Engineer	1-1-81	12-31-81	
J. A. Boock	Staff Assistant	3-1-84	11-03-84	Resigned
N. E. Bratton	Senior Administrative Assistant	2-1-83		
D. H. Cain	Engineering Technologist II	1-1-81		
E. E. Courtney	Engineering Technologist II	1-1-81		
J. D. Crabtree	Senior Research Engineer	1-1-81	2-12-83	Military Leave
T. Creasey	Transportation Research Engineer	6-10-81	5-17-85	Resigned
C. K. Crossfield	Research Analyst	1-1-81		
R. C. Deen	Director	1-1-81		
W. B. Drake	Associate Director	1-1-81	12-31-82	
J. M. Dunn	Staff Assistant	12-17-84	10-10-85	Resigned
		10-28-85		
D. L. Eaton	Engineering Technologist II	1-1-81	5-1-87	Resigned
T. Epperson	Staff Assistant	3-23-81	9-10-82	Transferred
C. S. Fetters	Staff Assistant	5-29-84	9-28-84	Resigned
L. J. Fleckenstein	Engineering Technologist II	6-15-87		
B. C. Gilpin	Engineering Technologist III	1-1-81	4-30-82	Resigned
M. M. Goetz	Laboratory Technician B	10-1-84	5-16-86	Resigned
C. G. Griffin	Administrative Assistant	3-7-81	1-3-83	Resigned
S. P. Hall	Transportation Research Engineer	7-7-86		
L. L. Hamon	Account Clerk	12-13-84		
F. G. Havens	Staff Assistant	1-1-81	1-22-81	Resigned
J. H. Havens	Associate Director	1-1-81	2-12-87	Retired
J. F. Hays	Staff Assistant	1-1-81	1-6-87	Died
L. A. Hensley	Program Analyst	1-1-81	6-22-84	Resigned
T. C. Hopkins	Senior Research Engineer	1-1-81		
T. Hopwood	Chief Research Engineer	1-1-81		
R. D. Hughes	Deputy Director	1-1-81		
D. Q. Hunsucker	Transportation Research Engr. Assoc.	1-7-85		
M. S. Isenhour	Entry Systems Analyst Programmer	9-24-84	6-5-87	Resigned
J. A. Jolly	Senior Laboratory Technician	1-1-81	12-31-81	
K. T. Lawson	Senior Engineering Aide	1-1-81	6-26-81	Transferred
W. C. Lawson	Senior Laboratory Technician	1-1-81	1-9-81	Resigned
J. G. Mayes	Chief Research Engineer	1-1-81	3-28-86	Resigned
B. W. Meade	Transportation Research Investigator	1-1-81		
J. E. Medina	Research Analyst	3-11-85	2-2-87	Resigned
L. A. Morris	Laboratory Technician B	1-1-81	12-11-81	Transferred
C. M. Oberst	Engineering Technologist II	6-27-87		
R. B. Pettitt	Laboratory Technician B	1-1-81	4-30-82	
W. J. Pfalzer	Senior Research Engineer	1-1-81	12-31-81	

J. G. Pigman	Chief Research Engineer	1-1-81		
K. R. Ranta	Laboratory Technician B	10-15-84	5-3-85	Transferred
R. D. Reitenour	Engineering Technologist II	1-1-81		
P. A. Riggs	Staff Assistant	2-16-87		
J. M. Salsman	Transportation Research Engineer	2-1-84	11-27-84	Resigned
T. C. Scully	Laboratory Technician Senior	1-1-81		
G. W. Sharpe	Chief Research Engineer	1-1-81		
H. F. Southgate	Chief Research Engineer	1-1-81		
J. S. Sutphin	Laboratory Technician B	10-15-84	11-15-84,	Resigned
C. T. Taraba	Senior Administrative Assistant	3-16-81	4-3-84,	Resigned
J. S. Thielges	Laboratory Technician B	6-22-85		
N. W. Tollner	Entry Systems Analyst Programmer	1-1-81		
J. S. Vice	Electronics Technician III	1-1-81	6-26-81,	Transferred
L. L. Watson	Laboratory Technician B	1-1-81	12-31-81,	Transferred
C. L. Wills	Senior Laboratory Technician	1-1-81	5-29-81,	Retired
D. R. Works	Laboratory Technician B	1-1-81	11-12-82	

NAME	POSITION	BEGINNING DATE	ENDING DATE
Temporary Employees			
D. Black	Clerical	6-1-83	6-30-83
J. D. Boock	Clerical	1-30-84	3-3-84
J. A. Boock	Clerical	1-20-84	2-29-84
N. E. Bratton	Clerical	1-3-83	1-30-83
C. S. Fetters	Clerical	4-4-84	5-28-84
G. Fugate, Jr.	Driller	10-26-81	12-18-81
M. Gaines	Clerical	3-7-84	3-30-84
M. Grobman	Clerical	5-28-85	6-27-85
J. M. Hahhaford	Driller	6-15-81	6-30-81
L. L. Hamon	Clerical	10-1-84	12-12-84
M. Hurst	Clerical	6-3-85	10-25-85
A. Kahn	Clerical	5-20-85	5-28-85
J. E. Lewis	Research Assistant	1-1-87	
S. Long	Clerical	8-23-83	1-6-84
J. E. Medina	Laboratory Technician	12-3-84	3-10-85
C. J. Sims	Research Assistant	1-1-85	8-31-85
E. Smile	Clerical	1-12-81	2-13-81
C. Tomblin	Clerical	6-24-85	8-9-85
L. A. Wesley	Clerical	10-30-84	1-4-85
P. Wingate	Clerical	3-8-83	4-29-83

Student Employees

N. Y. Ahmed	Undergraduate	5-19-87	
D. W. Armour	Graduate	5-7-84	12-13-84
B. A. Blair	Undergraduate	1-16-86	5-2-86
		9-2-86	5-15-87
K. S. Bohannon	Undergraduate	8-29-86	5-8-87
D. R. Boom	Undergraduate	9-1-83	4-28-84
J. T. Brown	Undergraduate	10-24-84	1-11-85
A. M. Carter	Undergraduate	9-1-83	5-4-84
J. L. Cline	Undergraduate	5-9-87	
J. W. Crowdus	Undergraduate	7-14-86	
N. A. Drake	Undergraduate	1-18-85	5-8-86
B. W. Fryman	Undergraduate	5-11-87	
K. E. Godshall	Graduate	2-23-87	
M. D. Gosnell	Undergraduate	1-13-84	5-4-84
S. P. Hall	Undergraduate	9-1-83	8-16-84
	Graduate	5-16-85	7-7-86
C. J. Hardin	Undergraduate	5-14-84	9-12-84
		8-25-85	12-12-85
J. R. Harville	Undergraduate	8-29-83	2-13-87
B. K. Hayes	Undergraduate	6-8-87	
D. R. Hudson	Undergraduate	9-1-83	12-1-83
D. Q. Hunsucker	Graduate	9-1-83	1-6-85
M. S. Isenhour	Undergraduate	8-29-83	9-24-84
A. S. Layson	Undergraduate	10-1-85	5-2-86
		9-8-86	

R. A. Ledford	Undergraduate	5-20-85	8-7-85
J. E. Lewis	Undergraduate	10-29-86	12-31-86
K. R. Meyer	Undergraduate	8-29-83	12-16-83
Z. M. Mohamed	Graduate	5-11-87	
A. Mohsenzadeh	Graduate	9-2-86	
V. G. Oka	Graduate	5-14-86	
E. F. Osumah	Graduate	9-1-83	3-31-84
D. L. Powell	Undergraduate	5-18-87	
G. R. Pratt	Undergraduate	5-13-85	8-21-86
D. K. Razor	Undergraduate	5-12-86	
R. E. Roberson	Undergraduate	12-3-84	5-7-86
H. M. Roghani	Graduate	1-22-87	
J. M. Salsman	Undergraduate	8-29-83	1-1-84
J. E. Salsman	Undergraduate	3-5-84	8-25-84
M. Sayyedsadr	Graduate	5-10-87	
J. L. Simmons	Undergraduate	1-15-86	4-30-86
		8-19-86	5-7-87
C. J. Sims	Undergraduate	6-16-84	12-31-84
		9-1-85	3-21-86
J. H. Spyhalski	Undergraduate	1-6-84	4-20-84
G. T. Stallard	Undergraduate	5-13-85	12-2-85
R. Stidham	Undergraduate	5-11-87	
J. D. Stockham	Undergraduate	5-7-84	11-10-84
		5-13-85	
T. G. Tjhang	Graduate	5-18-87	
S. K. Waddle	Graduate	1-5-87	
M. A. Waldron	Undergraduate	6-4-84	

Work/Study Students

H. Barbian	Undergraduate	9-10-84	5-24-85
M. Saladaris	Undergraduate	4-13-87	4-24-87

**ANNUAL SUMMARIES
OF ACTIVITIES**

SUMMARY OF ACTIVITIES
FISCAL YEAR 1981

ANNUAL SUMMARY, FY 1981

The Kentucky Transportation Research Program (KTRP) became a viable University entity on January 1, 1981, upon transfer of facilities, the majority of staff, and a major portion of equipment from the Kentucky Department of Transportation's Division of Research to the University's College of Engineering. An agreement provided total funding by the Department of Transportation for one calendar year for continuation of 62 studies.

Twenty-four reports were issued in FY 1981 and several received national and international recognition. Two papers were selected for special honors during the past year, one receiving runner-up recognition in the Association of Asphalt Paving Technologists' W. J. Emmons Award competition and the other receiving the Southern Section Institute of Transportation Engineers Best Technical Paper Award. Six reports were presented at the 1981 annual meeting of the Transportation Research Board.

Appreciable acceptance of study findings and resultant implementation of study recommendations have led to significant benefit-cost ratios for many studies undertaken by the unit. Values derived from research have been demonstrated routinely. Some of the work performed in FY 1981 resulted in development of a rapid consolidation test methodology, preparation of a retrieval guide for a soils data system, identification of unsafe areas on highway facilities, evaluation of performance and cost effectiveness of raised pavement markers, analyses of lane delineation procedures, and an evaluation of the structural condition of Ohio River suspension bridges. Adoption and implementation of study findings and recommendations provided potential for increased benefits from facility expenditures as well as increased safety. Additionally, considerable work was conducted in numerous other areas and impromptu investigations were made routinely.

Efforts were also directed toward preparation of informational materials for promotional purposes when contacting potential funding agencies. Responses were prepared to numerous requests for proposals and several unsolicited proposals were offered to various organizations. As a result, funds from other sources were secured and the availability of KTRP's services was publicized. A close working relationship between KTRP and the Institute for Mining and Minerals Research, as well as other University departments and offices, has evolved. KTRP was successful in rendering services at significant savings, and the necessity for contracting with outside agencies was eliminated in such cases. Staff members were involved in a number of professional organizations and activities and several served as part-time instructors in the UK College of Engineering.

REPORTS PUBLISHED, FY 1981

- 548 "Safety Improvement Program for Toll Roads," J. G. Pigman, K. R. Agent, and J. D. Crabtree, July 1980.
- 549 "Evaluation of Reversible Lanes (Nicholasville Road; Lexington, Kentucky)," K. R. Agent, and J. D. Clark, July 1980.
- 550 "Input Guide: Kentucky Soils Data System," W. J. Pfalzer, August 1980.
- 551 "Overlay Recommendations for I 64: Rowan, Carter, and Boyd Counties," G. W. Sharpe and H. F. Southgate, August 1980.
- 552 "Statewide Survey of Skid Resistance of Pavements (1979)," R. L. Rizenbergs and J. L. Burchett, September 1980.
- 553 "Modulus and Damping of Asphaltic Concrete Using the Resonant Column," D. L. Allen and R. C. Deen, September 1980; also Geotechnical Testing Journal.
- 554 "Frictional Performance of Pavements and Estimates of Accident Probability," J. L. Burchett, and R. L. Rizenbergs, September 1980.
- 555 "The Need for a Schema for the Classification of Transitional (Shale) Materials," R. C. Deen, October 1980; also Geotechnical Testing Journal.
- 561 "The Effect of Lane and Shoulder Widths on Accident Reduction on Rural, Two-Lane Roads," C. V. Zegeer, R. C. Deen, and J. G. Mayes, October 1980; also Record XXX, Transportation Research Board.
- 562 "Interpretation of Dynamic Pavement Deflections," G. W. Sharpe, H. F. Southgate, and R. C. Deen, October 1980.
- 564 "The Operation of an Electrical Heating System for Bridge Decks," W. V. Azevedo, R. C. Deen, and J. H. Havens, October 1980.
- 565 "Evaluation of the FHWA Highway Traffic Noise Prediction Procedure (SNAP 1)," K. R. Agent, October 1980; also Record XXX, Transportation Research Board.
- 566 "Interstate Safety Improvement Program," J. G. Pigman, K. R. Agent and C. V. Zegeer, November 1980; also Record XXX, Transportation Research Board.
- 568 "Use of Economic Analyses and Dynamic Programming in the Selection of Projects for Re-surfacing," C. V. Zegeer, K. R. Agent and R. L. Rizenbergs, November 1980; also Record XXX, Transportation Research Board.
- 570 "Frictional Performance of Pavements and Estimates of Accident Potential," J. L. Burchett and R. L. Rizenbergs, December 1980.
- UKTRP-81-1 "Survey of Effectiveness of Transportation Services," J. G. Pigman, K. R. Agent, and J. D. Crabtree, April 1981.
- UKTRP-81-2 "Survey of Lane Delineation Methods," K. R. Agent, April 1981.
- UKTRP-81-3 "Sprinkle-Treated Asphaltic Concrete Surface Course," D. C. Newberry, Jr., April 1981.

- UKTRP-81-4 "Retrieval Guide: Kentucky Soils Data System," W. J. Pfalzer and L. A. Hensley, April 1981.
- UKTRP-81-5 "Problem Identification for Highway Safety Plan (FY 1982)," J. G. Pigman, K. R. Agent, and J. D. Crabtree, May 1981.
- UKTRP-81-6 "Ohio River Suspension Bridges: An Inspection Report," Theodore Hopwood, June 1981.
- UKTRP-81-7 "Strain-Rate Selection in the Constant Rate-of-Strain Consolidation Test," C. T. Gorman, June 1981.
- UKTRP-81-8 "Evaluation of Raised Pavement Markers in Kentucky: Statewide Installation; 1975-1979," J. G. Pigman, K. R. Agent, and R. L. Rizenbergs, June 1981.
- UKTRP-81-9 "Traffic Accidents in Kentucky (1978)," K. R. Agent, June 1981.

PAPERS, FY 1981

- K. R. Agent, "Transverse Pavement Markings for Speed Control and Accident Reduction," Transportation Research Board Record 773, 1980.
- K. R. Agent, Traffic Accidents: Day Versus Night," Transportation Research Board Record 753, 1981.
- K. R. Agent, "Interstate Safety Improvement Program," Transportation Research Board Record 808, 1981.
- K. R. Agent, "Bicycle/Motor Vehicles Accidents in Kentucky," **Transportation Engineering Journal**, May 1980.
- D. L. Allen, and R. C. Deen, "Modulus and Damping of Asphaltic Concrete Using the Resonant Column, *Geotechnical Journal*, American Society of Testing and Materials, December 1980.
- D. L. Allen and R. C. Deen, "Rutting Models for Asphaltic Concrete and Dense-Graded Aggregate from Repeated Load Tests, Proceedings, Association of Asphalt Paving Technologists Annual Meeting and Technical Sessions, 1980.
- R. C. Deen, J. H. Havens, and W. V. Azevedo, "Cracking in PCC Pavements," American Society of Civil Engineers, 1980.
- R. C. Deen, "The Need for a Schema for the Classification of Transitional (Shale)Materials," *Geotechnical Testing Journal*, American Society for Testing and Materials, March 1981.
- R. C. Deen, C. V. Zegeer and J. G. Mayes, "Effect of Lane and Shoulder Widths on Accident Benefits for Rural, Two-Lane Roads," Transportation Research Board Record 806, 1981.
- J. G. Pigman, "Analysis of Weekday, Weekend, and Holiday Accident Frequencies, " *Traffic Quarterly*, July 1980.
- H. F. Southgate, G. W. Sharpe, R. C. Deen, "Interpretation of Dynamic Pavement Deflections," American Society of Civil Engineers, March, 1981.

PRESENTATIONS, FY 1981

- K. R. Agent, "Use of Economic Analysis and Dynamic Programming in the Selection of Projects for Resurfacing," Transportation Research Board Annual Meeting, January 1981.
- K. R. Agent, "Evaluation of the FHWA Highway Traffic Noise Prediction Procedure (SNAP 1)," Transportation Research Board Annual Meeting, January 1981.
- J. D. Crabtree, "Parking Opportunities," Southern Section Institute of Transportation Engineers, April 1981.
- R. C. Deen, J. G. Mayes, "Effect of Lane and Shoulder Widths on Accident Reduction on Rural, Two-Lane Roads," Transportation Research Board Annual Meeting, January 1981.

R. C. Deen, W. V. Azevedo, J. H. Havens, "Heating Bridge Decks by Electrical Resistance, Transportation Research Board Annual Meeting, January 1981.

W. B. Drake, "Value of Research to the Researcher, Economy and Society--View at the State Level," Transportation Research Board Annual Meeting, January 1981.

J. G. Pigman, K. R. Agent, "Interstate Safety Improvement Program," Transportation Research Board Annual Meeting, January 1981.

J. G. Pigman, K. R. Agent, "Snowplowable Marker Evaluation," Federal Highway Administration Workshop, Columbus, Ohio, February 1981.

AWARDS, FY 1981

American Public Works Association Outstanding Leadership and Service Award presented to W. B. Drake, 1981.

American Society of Civil Engineers (Management Group C) Certificate of Appreciation presented to W. B. Drake, 1981.

Association of Asphalt Paving Technologists W. J. Emmons Award presented to H. F. Southgate, R. C. Deen, J. G. Mayes for "Effect of Truck Design on Pavement Performance," February 1981.

Kentucky Society of Professional Engineers Award of Achievement for Engineering Service in Government presented to W. B. Drake, 1981.

Southern Section Institute of Transportation Engineers Best Technical Paper Award presented to J. G. Pigman and J. D. Crabtree for "Parking Opportunities," April 1981.

TRAINING, FY 1981

R. C. Deen, R. D. Hughes, J. G. Pigman, "Grantsmanship Training Program," Grantsmanship Training Center, March 1981.

R. C. Deen, "Value Engineering Workshop," Federal Highway Administration, New Albany, NY, 1981.

G. W. Sharpe, J. D. Crabtree, "Value Engineering Workshop," Federal Highway Administration, Louisville, KY, 1981.

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

- W. B. Drake, Director, Region III National Board, 1981.
- W. B. Drake, Member, Institute for Transportation, 1981.
- W. B. Drake, Member, Trustee Research Foundation, 1981.

American Society of Civil Engineers

- R. C. Deen, Member, Program Committee, Ohio River Valley Soils Seminar, 1981.
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group, 1981.
- W. B. Drake, Chairman, Management Group C, 1981.
- W. B. Drake, Member, Structural Design of Roadways Committee, 1981.

American Society for Testing and Materials

- R. C. Deen, Vice-Chairman, Committee on Publications, 1981.
- R. C. Deen, Member, Editorial Subcommittee of Committee on Soil and Rock (D-18), 1981.
- R. C. Deen, Member, Executive Subcommittee of Committee of Soils and Rock (D-18), 1981.
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18), 1981.
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18), 1981.

Association of Asphalt Paving Technologists

- H. F. Southgate, Publication Search Committee, 1980.

Institute of Transportation Engineers

- J. D. Crabtree, Secretary/Treasurer, Kentucky Division, Southern Section, 1981.
- J. G. Pigman, Member, Committee 5B3, Influence of Vehicle Design and Operating Characteristics on Roadway Design.

Kentucky Association of Transportation Engineers

- K. R. Agent, Member, Board of Directors, 1980.
- J. G. Pigman, President, 1980.

Kentucky Society of Professional Engineers

- J. G. Pigman, Member, Board of Directors, Bluegrass Chapter, 1981.

Transportation Research Board

- K. R. Agent, Instrumentation, Principles, and Applications Committee, 1981.
- R. C. Deen, Member, Chemical Stabilization Committee, 1981.
- R. C. Deen, Member, Earthwork Construction Committee, 1981.
- R. C. Deen, Member, Engineering Geology Committee, 1981.
- W. B. Drake, Member, Flexible Pavement Design Committee, 1981.
- W. B. Drake, Member, Subsurface Structure Design Committee, 1981.
- J. G. Pigman, Member, Methodology for Evaluating Highway Improvements Committee, 1981.
- J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee, 1981.
- G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavements Sections, 1981.
- H. F. Southgate, Member, Flexible Pavement Design Committee, 1981.
- H. F. Southgate, Member, Pavement Evaluation Committee, 1981.

Other

- W. B. Drake, Member, Program Committee, Kentucky Concrete Conference, 1981.

SUMMARY OF ACTIVITIES
FISCAL YEAR 1982

ANNUAL SUMMARY, FY 1982

The Kentucky Transportation Research Program recently completed its first full year as a department in the University of Kentucky College of Engineering. Faced with a difficult period of transition from the Kentucky Department of Transportation to the University and working under significant budget constraints, the program has succeeded in remaining a vital entity as well as an important and productive research organization.

During the fiscal year, 33 research studies and technology transfer activities were undertaken. Of those, 19 were funded by the Kentucky Department of Transportation. Other sources of funding included the Institute for Mining and Minerals Research; Riley, Park, Hayden & Associates, Inc.; Occidental Research Corporation; and the Lexington-Fayette Urban County Government/Bluegrass Area Development District. A total of \$1.2 million was granted for these studies during FY 1982. In all, 46 new proposals were prepared and submitted; of those, 36 proposals were funded.

Studies undertaken covered a broad range of areas within the transportation discipline. Traffic safety and operation studies included: performance and cost effectiveness of highway safety barriers and devices, investigation of accidents involving crash cushions, monitoring truck escape ramps, roadway delineation techniques using marking tapes and reflective traffic paint beads, design procedures for improvement of signalized intersections, identification of unsafe roadway areas, and development of methodology for allocation of the costs of transportation facilities to users in an equitable manner. Pavement mechanics and performance studies were conducted in the areas of rutting behavior of pavements, pavement texture, skid resistance, and pavement evaluation (condition). Materials characterization and behavior studies were undertaken on shale materials that have caused extensive maintenance problems, slope stability analyses, soil-bridge abutment behavior, embankment forces on culverts placed under high fills, and fatigue analyses of metal bridge components. As a result of these studies, 18 reports were published through KTRP and seven papers were published in leading national and international journals.

The significance of study findings has been evidenced by widespread implementation of recommendations presented in those reports. The American Association of State Highway and Transportation Officials revised design guidelines relating to culvert loading based upon data obtained from a KTRP study. The 1982 Kentucky Legislature utilized data and recommendations of a KTRP study in their development of a weight-distance tax structure for trucks. A fracture-control plan for the Thirteenth Street Bridge at Ashland was developed from information gathered in a study concerning fatigue properties of metals. It is the opinion of many

that implementation of the fracture-control plan probably reduced the probability of catastrophic failure of that structure. Numerous other study findings have been implemented and their benefit-cost ratios have been attractive.

The research studies were conducted by a team of 14 research engineers and 15 technicians and support staff. Engineers were active in professional organizations and various training programs throughout the year to keep abreast of rapidly changing technology, management, and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees.

Staff members are frequently called upon to share their expertise with organizations outside the program. Four engineers made presentations at the 1982 annual meeting of the Transportation Research Board in Washington, DC, and two presentations were accepted for the 1983 annual meeting. Slide presentations were made to the Kansas and Florida Departments of Transportation. Various conferences, short courses, symposiums, and workshops were administered and taught by staff members. A number of engineers also served as part-time instructors in UK's College of Engineering.

During the year, KTRP has developed or obtained several new pieces of valuable equipment. The use of that equipment has enabled researchers to conduct unique research. For instance, the development of a portable retroreflectometer is allowing researchers to more accurately and consistently determine reflectivity of pavement markings in the field. Also aiding safety research is a speed classifier used to determine speed distributions. In other areas, a pavement condition recorder has been utilized in recording Road Rater deflection measurements. Computer facilities added in the past year include two controllers, six CRT terminals, a line printer, a decwriter, and a televideo dial-up terminal. Plans are being made to implement script photo typesetting, which will enable production of high-quality typeset documents from the Program's Script files and significantly reduce costs of producing reports.

REPORTS PUBLISHED, FY 1982

- UKTRP-81-10 "Identification and Rehabilitation of High-Risk Drivers," K. R. Agent, July 1981.
- UKTRP-81-11 "Evaluation of Rumble Strip Design and Usage," J. G. Pigman and M. M. Barclay, July 1981.
- UKTRP-81-12 "Evaluation of Watertight Bridge Expansion Joints," W. V. Azevedo, July 1981.
- UKTRP-81-13 "Vehicle Noise Emission Levels in Kentucky," K. R. Agent, July 1981.
- UKTRP-81-14 "Analysis of Time-deflection Consolidation Data," E. G. McNulty, August 1981.
- UKTRP-81-15 "Identification, Analyses, and Correction of High-Accident Locations in Kentucky," C. V. Zegeer, K. R. Agent, and R. L. Rizenbergs, August 1981.
- UKTRP-81-16 "Identification of Kentucky Shales," T. C. Hopkins and B. C. Gilpin, August 1981.
- UKTRP-81-17 "Design Guide for Bituminous Concrete Pavement Structures," J. H. Havens, R. C. Deen, and H. F. Southgate, August 1981.
- UKTRP-81-18 "Structural Capacity of In-Place Asphaltic Concrete Pavements from Dynamic Deflections," H. F. Southgate, G. W. Sharpe, R. C. Deen, and J. H. Havens, August 1981.
- UKTRP-81-19 "Evaluation of Pavement Tape as Lane Delineation," J. G. Pigman and K. R. Agent, November 1981.
- UKTRP-81-20 "Development of a Thickness Design System for Bituminous Concrete Pavements," H. F. Southgate, R. C. Deen, and J. H. Havens, November 1981.
- UKTRP-81-21 "Propagation of Traffic Noise," K. R. Agent, and C. V. Zegeer, November 1981.
- UKTRP-81-22 "Allocation of Transportation Costs to Users," J. E. Black, and J. G. Pigman, November 1981.
- UKTRP-82-1 "Aggregate Shape and Skid Resistance," J. H. Havens, January 1982.
- UKTRP-82-2 "Correlation of Road Rater and Benkelman Beam Deflections," R. C. Deen, G. W. Sharpe, and H. F. Southgate, January 1982 (International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 23-25, 1982).
- UKTRP-82-3 "Implementation of Road Rater Deflection Testing for Pavement Evaluation and Overlay Design," G. W. Sharpe, H. F. Southgate, and R. C. Deen, January 1982 (International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 23-25, 1982).
- UKTRP-82-4 "Pavement Testing...Before and After an Overlay," H. F. Southgate, G. W. Sharpe, and R. C. Deen, January 1982 (International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 23-25, 1982).
- UKTRP-82-5 "Problem Identification for Highway Safety Plan (FY 1983)," K. R. Agent, J. D. Crabtree, J. G. Pigman, May 1982.
- UKTRP-82-6 "Triaxial Compression and Permeability Tests on Dense-Graded Aggregate," D. L. Allen, May 1982.

- UKTRP-82-7 "Evaluation of Snowplowable Markers," J. G. Pigman and K. R. Agent, May 1982.
- UKTRP-82-8 "Analysis of Saturation Flow at Signalized Intersections," K. R. Agent and J. D. Crabtree, May 1982.

PAPERS, FY 1982

K. R. Agent, C. V. Zegeer, "Effect of Interrupted Flow on Traffic Noise," *Noise Control Engineering*, March-April 1982.

K. R. Agent, "An Evaluation of Permissive Left-Turn Phasing," *ITE Journal*, December 1981.

R. C. Deen, G. W. Sharpe, and H. F. Southgate, "Correlation of Road Rater and Benkelman Beam Deflections, International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 1982.

R. C. Deen, G. W. Sharpe, H. F. Southgate, "Implementation of Road Rater Deflection Testing for Pavement Evaluation and Overlay Design," International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 1982.

W. B. Drake, "Case History: KY 80 Resource Recovery Road Concrete Construction," Nineteenth Kentucky Concrete Conference, November 1981.

J. G. Pigman, "Minimum Resources Required to Use Accident Statistics and Safety-Related Data for Highway Safety Program Administration," *Transportation Research Circular*, Number 233, 1981.

H. F. Southgate, G. W. Sharpe, and R. C. Deen, "Pavement Testing -- Before and After an Overlay," International Symposium on Bearing Capacity of Roads and Airfields, Trondheim, Norway, June 1982.

PRESENTATIONS, FY 1982

K. R. Agent, "Noise Propagation," Transportation Research Board Annual Meeting, January 1982.

D. L. Allen and T. C. Hopkins, "Engineering Properties of Kentucky Oil Shales," Symposium on Eastern Oil Shales, November 1981.

J. D. Crabtree and J. A. Deacon, "Highway Sizing," Transportation Research Board Annual Meeting, January 1982.

R. C. Deen, "Basic Soil Mechanics," Short course taught at Institute for Mining and Minerals Research, January 1982.

R. C. Deen, "Basic Soil Mechanics," Short course taught at Southwest Virginia Community College, November 1981.

R. C. Deen, "Slope Stability," Short course taught at Institute for Mining and Minerals Research, March 23-24, and March 25-26, 1982.

R. C. Deen, "Maintenance Management," Cumberland Falls Area Development District, London, April 1982.

R. C. Deen, "Drilling and Sampling of Subsurface Materials" Short course taught at Institute for Mining and Minerals Research, May 1982.

R. C. Deen and H. F. Southgate, "Pavement Damage Factors," Slide presentation presented to Florida DOT and Kansas DOT, 1982.

R. C. Deen, Presider, Kentucky Asphalt Conference, March 1982.

W. B. Drake, "Asphalt Pavement Recycling: Cold Mix-Inpace," Kentucky Asphalt Conference, March 1982.

W. B. Drake, "Kentucky Transportation Research Program," Bluegrass Area Development District, January 1982.

W. B. Drake, "Kentucky Transportation Research Program," Capital Branch American Society of Civil Engineers, February 1982.

W. B. Drake, "Transportation Engineering," (CE 340) Department of Civil Engineering, Spring 1982.

J. H. Havens, "Technolgy Update," American Public Works Association, Opryland, April, 1982.

J. G. Pigman, "Minimum Resources Required to Use Accident Statistics and Safety-Related Data for Highway Safety Program Administration," Transportation Research Board Workshop, King's Island, Ohio, August 1981.

J. G. Pigman and J. D. Crabtree, "Small Car Parking Opportunities," Transportation Research Board Annual Meeting, January 1982.

H. F. Southgate, "Inventory Condition Survey and Program Development--Local Roads and Streets," First Kentucky Conference on Asphalt Pavements, March 1982.

H. F. Southgate, "Road Maintenance" Workshop, Cumberland Valley Area Development District, London, Kentucky, April 28, 1982.

TRAINING, FY 1982

R. C. Deen, "Time Management for Managers," University of Kentucky, Human Resource Developement, March 1982.

J. H. Havens, R. C. Deen, H. F. Southgate, and G. W. Sharpe, "Pavement Rehabilitation," Federal Highway Administration, April 1982.

H. F. Southgate and G. W. Sharpe, "Bridge Inspection," Kentucky Department of Transportation April-May 1982.

T. C. Hopkins, "Hydraulics and Hydrology of Dam Design," University of Missouri, May 1982.

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Society of Civil Engineers

- R. C. Deen, Member, Program Committee, Ohio River Valley Soils Seminar, 1982
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group, 1982.
- W. B. Drake, Member, Management Group C, 1982.
- W. B. Drake, Member, Structural Design of Roadways Committee, 1982.
- J. H. Havens, Member, Awards Committee, Kentucky Chapter, 1982.

American Society for Testing and Materials

- R. C. Deen, Vice-Chairman, Committee on Publications, 1982.
- R. C. Deen, First Vice-Chairman, Committee on Soil and Rock (D-18), 1982.
- R. C. Deen, Member, Editorial Subcommittee of Committee on Soil and Rock (D-18), 1982.
- R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18), 1982.
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18), 1982.
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18), 1982.

Institute of Transportation Engineers

- K. R. Agent, Member, Design of Truck Escape Ramps Committee, 1982.
- K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee, 1982.
- J. D. Crabtree, Secretary/Treasurer, Kentucky Division, Southern Section, 1982.
- J. G. Pigman, Member, Influence of Vehicle Design and Operating Characteristics on Roadway Design Committee, 1982.
- J. G. Pigman, Member, 1983 Annual Meeting Planning Committee, Southern Section.

Kentucky Society of Professional Engineers

- J. H. Havens, Member, Professional Conduct Committee, Bluegrass Chapter, 1982.
- J. G. Pigman, Member, 1982 Annual Convention Planning Committee.
- J. G. Pigman, Member, Board of Directors, Bluegrass Chapter, 1982.

Transportation Research Board

- K. R. Agent, Member, Instrumentation, Principles, and Applications Committee, 1982.
- R. C. Deen, Chairman, Group 2 Council, Design and Construction of Transportation Facilities, 1982.
- R. C. Deen, Member, Chemical Stabilization Committee, 1982.
- R. C. Deen, Member, Earthwork Construction Committee, 1982.
- R. C. Deen, Member, Engineering Geology Committee, 1982.
- W. B. Drake, Member, Flexible Pavement Design Committee, 1982.
- W. B. Drake, Member, Subsurface Structure Design Committee, 1982.
- J. G. Pigman, Member, Methodology for Evaluating Highway Improvements Committee, 1982.
- J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee, 1982.
- G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavement Sections, 1982.
- H. F. Southgate, Member, Flexible Pavement Design Committee, 1982.
- H. F. Southgate, Member, Pavement Evaluation Committee, 1982.

Others

- W. B. Drake, Member, Education Committee, Association of General Contractors, 1982.
- W. B. Drake, Chairman, Program Committee, Kentucky Asphalt Conference, 1982.
- W. B. Drake, Member, Program Committee, Kentucky Concrete Conference, 1982.
- H. F. Southgate, Member, Technical Advisory Committee, 5th International Conference, Structural Design of Asphalt Pavements, Netherlands, 1982.
- H. F. Southgate, Consultant to Governor's Task Force on Coal Haul Roads, 1982.

**SUMMARY OF ACTIVITIES
FISCAL YEAR 1983**

ANNUAL SUMMARY, FY 1983

The Kentucky Transportation Research Program completed its second full year as a department in the University of Kentucky College of Engineering on a positive note. Negotiations for the 1984 Fiscal Year program were successful and seemed to indicate the program had moved through a difficult period of transition from the Kentucky Department of Transportation to the University.

During the fiscal year, 48 research studies and technology transfer activities were undertaken. Of those, 23 were funded by the Kentucky Department of Transportation. Other sources of funding included the Institute for Mining and Minerals Research, US Army Corps of Engineers, University of Tennessee Transportation Center, Kentucky State Police, Kentucky Department of Natural Resources, Carey Construction Company, City of Highland Heights, and the Lexington-Fayette Urban County Government/Bluegrass Area Development District. Approximately \$1.0 million was granted for these studies during FY 1983. In all, 45 proposals were prepared and submitted to various agencies; 28 proposals were funded.

Studies undertaken covered a broad range of areas within the transportation discipline. Traffic safety and operation studies included: performance and cost effectiveness of highway safety barriers and devices, investigation of accidents involving crash cushions, monitoring truck escape ramps, roadway delineation techniques using marking tapes and reflective traffic paint beads, design procedures for improvement of signalized intersections, identification of unsafe roadway areas, and development of methodology for allocation of the costs of transportation facilities to users in an equitable manner. Pavement mechanics and performance studies were conducted in the areas of rutting behavior of pavements, pavement texture, skid resistance, and pavement evaluation (condition). Materials characterization and behavior studies were undertaken on shale materials that have caused extensive maintenance problems, slope stability analyses, soil-bridge abutment behavior, embankment forces on culverts placed under high fills, and fatigue analyses of metal bridge components. As a result of these studies, 28 reports were published through KTRP and eight papers were published in leading national and international journals.

The significance of study findings has been evidenced by widespread implementation of recommendations presented in those reports. A methodology, based upon theory and performance data, was developed for rigid pavement thickness designs. Testing procedures were perfected to provide for extensive use of the Road Rater in pavement surface, base, and subbase evaluation programs. The Traffic Alcohol Program was so uniquely significant that it has been greatly expanded to include several other municipalities. The evaluation has received

considerable local, state, and federal publicity. A portable retroreflectometer was developed for quantitative evaluation of pavement marking materials. That unit provides for objective evaluation of marking materials. A comprehensive computer program developed for slope stability analyses of highway embankments overcomes some shortcomings of currently available programs.

The research studies were conducted by a team of 12 research engineers and 14 technicians and support staff. Engineers were active in professional organizations and various training programs throughout the year to keep abreast of rapidly changing technology and management and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees. One engineer received the Robert M. Gilliam Professional Recognition Award (from the Kentucky Section of the American Society of Civil Engineers) for outstanding contributions in engineering and community leadership.

Staff members are frequently called upon to share their expertise with organizations outside the program. Three presentations were made at the 1983 annual meeting of the Transportation Research Board in Washington, DC. Presentations were made to the West Virginia, Oklahoma, and national asphalt paving associations and at the international conference in The Netherlands. Various short courses, symposiums, and workshops were administered and taught by staff members. One engineer also served as a part-time instructor in UK's College of Engineering.

REPORTS PUBLISHED, FY 1983

- UKTRP-82-9 "Pavement Roughness in Kentucky," G. W. Sharpe, D. H. Cain, H. F. Southgate, J. H. Havens, and R. C. Deen, July 1982.
- UKTRP-82-10 "Summary of Vehicle Classification Data," J. D. Crabtree, August 1982.
- UKTRP-82-11 "Traffic Accident Rates in Kentucky (1980), K. R. Agent, August 1982.
- UKTRP-82-12 "Accident Rates by Vehicle Type," J. D. Crabtree and K. R. Agent, August 1982.
- UKTRP-82-13 "Highway Sizing," J. D. Crabtree and J. A. Deacon, August 1982.
- UKTRP-82-14 "Snow-Melting System, 9th Street and I 64, Louisville," W. V. Azevedo, September 1982.
- UKTRP-82-15 "Child Restraint Usage in Kentucky (Pre-Legislation)," K. R. Agent and J. D. Crabtree, September 1982.
- UKTRP-82-16 "Mechanical and Engineering Properties of a Cherty Paleozoic Material," R. C. Deen, D. L. Allen, and T. C. Hopkins, September 1982.
- UKTRP-82-17 "Deflection and Evaluation of Flexible Pavements for Design of Overlays," H. F. Southgate, G. W. Sharpe, and R. C. Deen, September 1982.
- UKTRP-82-18 "Effects of Construction Variations upon Dynamic Moduli of Asphaltic Concrete," H. F. Southgate, October 1982; also *Proceedings, The Association of Asphalt Paving Technologists*.
- UKTRP-82-19 "Warrants for Left-Turn Lanes," K. R. Agent, October 1982; also, *Transportation Quarterly*, January 1983.
- UKTRP-82-20 "Engineering Properties of Kentucky Oil Shales," V. P. Drnevich, T. C. Hopkins, D. L. Allen, S. S. Hale, October 1982; also *Proceedings, Eastern Kentucky Oil Shale Symposium*, November 1981.
- UKTRP-82-21 "Mechanical Properties of Kentucky Oil Shales as Related to Mine Design Application," T. F. Fudge, Jr., D. L. Allen, and T. C. Hopkins, October 1982; also *Proceedings, Eastern Oil Shale Symposium*, October 1982.
- UKTRP-82-22 "Review of Pertinent Contract Documents: Tennessee-Tombigbee Waterway, Divide Cut Section 3A," R. D. Hughes, R. C. Deen, D. L. Allen, T. C. Hopkins, November 1982.
- UKTRP-82-23 "Strain Energy Analysis of Pavement Designs for Heavy Trucks," H. F. Southgate, R. C. Deen, J. G. Mayes, November 1982; also *TRB*.
- UKTRP-82-24 "Engineering Properties of Overburden Materials for the Means Project," V. P. Drnevich, D. L. Allen, T. C. Hopkins, December 1982.
- UKTRP-83-1 "Sandstone as a Construction Materials: KY 80, Hazard to Watergap," G. W. Sharpe, H. F. Southgate, D. L. Allen, J. H. Havens, and R. C. Deen, January 1983.
- UKTRP-83-2 "Mechanical and Engineering Properties of a Cherty Paleozoic Material: A Supplemental Report," R. C. Deen, D. L. Allen, and T. C. Hopkins, January 1983.
- UKTRP-83-3 "Analysis of Lost Times at Signalized Intersections," K. R. Agent and J. D. Crabtree, February 1983.

- UKTRP-83-4 "Traffic Safety Analysis: University of Kentucky Area," February 1983.
- UKTRP-83-5 "Development of a Thickness Design System for Portland Cement Concrete Pavements," H. F. Southgate, J. H. Havens, R. C. Deen, D. C. Newberry, February 1983.
- UKTRP-83-6 "Computerized Analysis of Flexible Pavement Rutting Behavior (PAVRUT)," D. Allen, February 1983.
- UKTRP-83-7 "Engineering Properties of Two Spent Shales and Minus 1/4-inch Raw Shale for the Means Project," V. P. Drnevich, D. L. Allen, and T. C. Hopkins, February 1983.
- UKTRP-83-8 "Design of Oil Shale Disposal Embankments," V. P. Drnevich, T. C. Hopkins, and S. S. Hale, February 1983; also *Proceedings*, 1982 Eastern Oil Shale Symposium, October 1982, Lexington, Ky.
- UKTRP-83-9 "Development of a Portable Retroreflectometer," K. R. Agent and J. G. Pigman, April 1983.
- UKTRP-83-10 "Improved Structural Monitoring with Acoustic Emission Pattern Recognition," D. W. Prine and T. Hopwood, April 1983.
- UKTRP-83-11 "Traffic Accident Rates in Kentucky (1981)," K. R. Agent, May 1983.

PAPERS, FY 1983

- T. F. Fudge, D. L. Allen, and T. C. Hopkins, "Mechanical Properties of Kentucky Oil Shale as Related to Mine Design Application," *Proceedings*, 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- J. G. Pigman and J. D. Crabtree, "Opportunities for Small-Car Parking," Research Record 845, Transportation Research Board, 1982.
- K. R. Agent, "Evaluation of Reversible Lanes," *Traffic Engineering and Control*, November 1982.
- K. R. Agent, "Warrants for Left-Turn Lanes," *Transportation Quarterly*, January 1983.
- D. W. Prine and Theodore Hopwood, "Improved Structural Monitoring with Acoustic Emission Pattern Recognition," Annual Symposium on Nondestructive Evaluation, April 1983.
- J. M. Hower, R. I. Barnhise, and T. C. Hopkins, "The Borden and Bedford as Topsoil Substitutes," *Proceedings*, 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," *Proceedings*, 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- H. F. Southgate, G. W. Sharpe, R. C. Deen, and J. H. Havens, "Structural Capacity of In-Place Asphaltic Concrete Pavements from Dynamic Deflections," *Proceedings*, Fifth International Conference on Asphalt Pavement Design, Delft, The Netherlands, August 1982.

PRESENTATIONS, FY 1983

- J. H. Havens, "Pavement Thickness Design," Kentucky Asphalt Conference, April 7-8, 1983.
- G. W. Sharpe, "Pavement Evaluations and Overlay Design -- I 64; Rowan, Carter, and Boyd Counties," Kentucky Asphalt Conference, April 7-8, 1983.

- T. F. Fudge, D. L. Allen, T. C. Hopkins, "Mechanical Properties of Kentucky Oil Shale as Related to Mine Design Application," 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- J. G. Pigman and K. R. Agent, "Field Evaluation of Snowplowable Pavement Markers," Annual Meeting, Transportation Research Board, January 1983.
- J. G. Pigman and K. R. Agent, "Pavement Marking -- What's in the Future?" Technical Meeting, Kentucky Division, Southern Section Institute of Transportation Engineers, November 1982.
- R. D. Hughes, "Basic Mathematics and Estimating," Workshop, Cumberland Valley Area Development District, London, Kentucky, March 1983.
- D. W. Prine and Theodore Hopwood, "Improved Structural Monitoring with Acoustic Emission Pattern Recognition," Annual Symposium on Nondestructive Testing, San Antonio, Texas, April 1983.
- Theodore Hopwood, Series of Lectures on Nondestructive Testing, Bluegrass Chapter, American Society of Metals, 1982-83.
- R. C. Deen, "Drilling and Sampling of Subsurface Materials," Short Course taught at Institute for Mining and Minerals Research, September 28-29, 1982.
- R. C. Deen, "Stability Analysis of Refuse Embankments, Hollow Fills and Spoil Banks," Workshop taught at Institute for Mining and Mineral Research, November 15-16, 1982.
- R. C. Deen, "Stability Analysis of Refuse Embankments, Hollow Fills and Spoil Banks," Workshop taught at Institute for Mining and Mineral Research, November 22-23, 1982.
- R. C. Deen, "Fundamentals of Geotechnical Engineering," Short Course taught at Institute for Mining and Minerals Research, March 7-8, 1983.
- R. C. Deen, "Maintenance Management," Annual Meeting, Council of Area Development Districts, Lexington, July 19, 1982.
- R. C. Deen, "Kentucky Transportation Research," Meeting of Research Engineers of FHWA Regions 4 and 6, Arlington, Texas, July 21-23, 1982.
- Theodore Hopwood, "Acoustic Emission Inspection of Bridges," Annual Meeting, Structures Maintenance, Committee, Transportation Research Board, January 1983.
- G. W. Sharpe, "Use of Road Rater," Kentucky Division, Federal Highway Administration, March 1983.
- G. W. Sharpe, "Use of Road Rater," Engineering Staff, Kentucky Department of Highways, March 1983.
- G. W. Sharpe, "PE Review Courses -- Highway Capacity and Pavement Design," University of Kentucky, March 1983.
- J. M. Hower, R. I. Barnhisle and T. C. Hopkins, "The Borden and Bedford as Topsoil Substitutes," 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," 1982 Eastern Oil Shale Symposium, October 11-13, 1982.
- V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," Kentucky Geotechnical Engineering Group, February 1983.
- V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," Civil Engineering Seminar, University of Michigan, Spring 1983.

V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," Civil Engineering Seminar, University of Notre Dame, Winter 1982-83.

V. P. Drnevich, T. C. Hopkins, and S. S. Hale, "Design of Oil Shale Disposal Embankments," Civil Engineering Seminar, Ohio State University, Spring 1983.

H. F. Southgate, G. W. Sharpe, R. C. Deen, and J. H. Havens, "Structural Capacity of In-Place Asphaltic Concrete Pavements from Dynamic Deflections," Fifth International Conference on Asphalt Pavement Design, Delft, The Netherlands, August 1982.

H. F. Southgate, R. C. Deen, and J. G. Mayes, "Strain Energy Analysis of Pavement Designs for Heavy Trucks," Annual Meeting, Transportation Research Board, January 1983.

H. F. Southgate, "Recent Pavement Design Considerations," Annual Meeting, Transportation Research Board, January 1983.

H. F. Southgate, "Testing to Determine the Modulus of Fragmented Concrete," Annual Meeting, National Asphalt Pavement Association, Phoenix, Arizona, February 1983.

H. F. Southgate, "Testing to Determine the Modulus of Fragmented Concrete," Annual Meeting, Flexible Pavements Council of West Virginia, Charleston, March 1983.

H. F. Southgate, "Testing to Determine the Modulus of Fragmented Concrete," Oklahoma Asphalt Pavement Association, June 1983.

AWARDS, FY 1983

1982 Robert M. Gillam Professional Recognition Award (from Kentucky Section, American Society of Civil Engineers) to W. B. Drake for outstanding contributions in the field of engineering and community leadership, September 1982.

TRAINING, FY 1983

R. C. Deen, "Concrete Pavement Rehabilitation Demonstration," Ohio Concrete Paving Association and General Electric Co., Cambridge, Ohio, September 15, 1983.

R. C. Deen, "Accident Reconstruction," University of Kentucky, August 1-2, 1982.

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

- R. C. Deen, Member.
- W. B. Drake, Member.
- J. H. Havens, Member.

American Society of Civil Engineers

- D. L. Allen, Member.
- D. L. Allen, Program Chairman, Kentucky Geotechnical Engineering Group.
- D. L. Allen, Member, Program Committee, 1982 Ohio River Valley Soils Seminar.
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group, 1983.
- W. B. Drake, Member, Management Group C, 1982.
- W. B. Drake, Member, Structural Design of Roadways Committee, 1983.
- J. H. Havens, Member.
- T. C. Hopkins, Member.
- T. C. Hopkins, Member, Geotechnical Engineering Group.

American Society for Testing and Materials

- R. C. Deen, Vice-Chairman, Committee on Publications, 1983.
- R. C. Deen, First Vice-Chairman, Committee on Soil and Rock (D-18), 1983.
- R. C. Deen, Chairman, Editorial Subcommittee on Soil and Rock (D-18), 1983.
- R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18), 1983.
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18), 1983.
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18), 1983.

Institute of Transportation Engineers

- K. R. Agent, Member, 1983 Annual Meeting Planning Committee, Southern Section.
- K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee, 1983.
- J. D. Crabtree, Secretary/Treasurer, Kentucky Division, Southern Section, 1983.
- J. G. Pigman, Member, Influence of Vehicle Design and Operating Characteristics on Roadway Design Committee, 1983.
- J. G. Pigman, Member, 1983 Annual Meeting Planning Committee, Southern Section.
- R. C. Deen, Member.
- G. W. Sharpe, Member.

Kentucky Society of Professional Engineers

- D. L. Allen, Member.
- R. C. Deen, Member, Chairman of History Committee.
- J. H. Havens, Member.
- J. G. Pigman, Member.
- J. G. Pigman, Chairman, House Committee, Bluegrass Chapter, 1983.
- T. C. Hopkins, Member.
- H. F. Southgate, Member.

Transportation Research Board

- K. R. Agent, Member, Instrumentation Principles and Applications Committee, 1983.
- R. C. Deen, Chairman, Group 2 Council, Design and Construction of Transportation Facilities, 1983.
- R. C. Deen, Member, Chemical Stabilization Committee, 1983.
- R. C. Deen, Member, Earthwork Construction Committee, 1983.
- R. C. Deen, Member, Engineering Geology Committee, 1983.
- W. B. Drake, Member, Subsurface Structure Design Committee, 1983.
- J. G. Pigman, Member, Methodology for Evaluating Highway Improvements Committee, 1983.
- J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee, 1983.
- G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavement Sections, 1983.

- H. F. Southgate, Member, Flexible Pavement Design Committee, 1983.
- H. F. Southgate, Member, Pavement Evaluation Committee, 1983.
- G. W. Sharpe, Member, Rigid Pavement Committee, 1983.

Others

- D. L. Allen, Organizing Committee, International Symposium on Urban Hydrology.
- W. B. Drake, Member, Education Committee, Association of General Contractors, 1983.
- W. B. Drake, Chairman, Program Committee, Kentucky Asphalt Conference, 1983.
- H. F. Southgate, Member, Technical Advisory Committee, 5th International Conference, Structural Design of Asphalt Pavements, The Netherlands, 1983.
- H. F. Southgate, Member, The Association of Asphalt Paving Technologists, 1983.
- J. H. Havens, Member, Association of Asphalt Paving Technologists.
- T. Hopwood, Member, American Welding Society.
- T. Hopwood, Member, American Society for Metals.
- T. Hopwood, Member, American Society for Nondestructive Testing.
- T. Hopwood, Program Chairman for Highway Session, 1983 American Society for Nondestructive Testing Conference.

International Society of Soil Mechanics and Foundation Engineers

- T. C. Hopkins, Member.
- R. C. Deen, Member.

SUMMARY OF ACTIVITIES
FISCAL YEAR 1984

Annual Summary, FY 1984

The Kentucky Transportation Research Program completed its third full year as a department within the University of Kentucky College of Engineering in a positive manner. Fiscal Year 1984 saw a significant increase in the research program for the Transportation Cabinet; additional studies were approved along with an increased budget above the fiscal 1983 level.

During the fiscal year, procedures were developed to provide for short-term research studies funded through Federal Aid Research Task orders. Other funding sources became available and were awarded under the Federal Highway Administration's Demonstration Projects and Experimental Projects programs. Additional research studies were conducted for the Kentucky State Police, the Kentucky Department of Natural Resources, US Army Corps of Engineers, the Lexington-Fayette Urban County Government, Carey-Construction Company, Mineral By-Products Incorporated, City of Louisville, Island Creek Coal Corporation, and the Northern Kentucky Area Development District. Approximately \$1.3 million was granted for these studies during FY 1984, representing an increase of approximately 30 percent above monies received during FY 1983.

Studies undertaken covered a broad range of areas within the transportation discipline. Traffic safety and operation studies included performance and cost effectiveness of highway safety barriers and devices, investigation of accidents involving crash cushions, monitoring truck escape ramps, roadway delineation techniques using marking tapes and reflective traffic paint beads, design procedures for improvement of signalized intersections, and identification of unsafe roadway areas. Pavement mechanics and performance studies were conducted in the areas of rutting behavior of pavements, pavement texture, skid resistance, and structural condition of pavements. Materials characterization and behavior studies were undertaken on shale materials that have caused extensive maintenance problems, slope stability analyses, soil-bridge abutment behavior, forces on culverts under high fills, and fatigue analyses of metal bridge components. As a result of these studies, 36 reports were issued and seven papers were published in leading national and international journals.

The significance of study findings has been evidenced by widespread implementation of recommendations presented in those reports. A methodology, based upon theory and performance data, was developed for rigid pavement as well as flexible pavement thickness designs. Testing procedures were perfected to provide for extensive use of the Road Rater in pavement surface, base, and subbase evaluation programs. The Road Rater was used to obtain data to assist in preparing recommendations for rehabilitation strategies for highways in Kentucky; Tennessee; Lexington, Kentucky; and Highland Heights, Kentucky. The Traffic Alcohol Program was so uniquely significant that it has been greatly expanded to include several other municipalities. The evaluation has received considerable local, state, and federal publicity. Studies were undertaken to evaluate the utilization and effectiveness of child restraints. A comprehensive computer program developed for slope stability analyses of embankments overcomes some shortcomings of currently available programs and is now being implemented by the Kentucky Department of Highways. Studies of low-strength waste or low-

cost materials were undertaken to evaluate feasibility and effectiveness of those materials in highway construction.

The Research Program was conducted by a team of 14 research engineers and 17 technicians and support staff. Engineers were active in professional organizations and various training programs throughout the year to keep abreast of rapidly changing technology and management and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees.

Staff members are frequently called upon to share their expertise with organizations outside the program. Two presentations were made at the 1984 annual meeting of the Transportation Research Board in Washington, D.C. Twelve other presentations were made to such organizations as the Michigan Asphalt Pavement Association, International Forum on Traffic Records Systems, American Concrete Institute convention, American Society of Nondestructive Testing, Ohio Transportation Engineering Conference, Southeastern States Dam Safety Conference, International Conference on Economic and Environmental Utilization of Kiln Dust and Kiln Dust/Fly Ash Technology, and American Society for Testing and Materials. Various short courses, symposiums, and workshops were administered and taught by staff members. Two engineers also served as part-time instructors in UK's College of Engineering.

REPORTS PUBLISHED, FY 1984

- UKTRP-83-12 "User's Manual for Dynamic Programming for Highway Safety Improvement Program," J. D. Crabtree and J. G. Mayes, July 1983.
- UKTRP-83-13 "Water under Pavements," J. H. Havens and G. W. Sharpe, July 1983.
- UKTRP-83-14 "Geotechnical, Hydrologic, and Hydraulic Investigation of Mill Creek Dam -- Phase II," T. C. Hopkins, R. D. Hughes, and D. L. Allen, July 1983.
- UKTRP-83-15 "Crushed Rock Bases," J. H. Havens and G. W. Sharpe, August 1983.
- UKTRP-83-16 "Identification of Shales," T. C. Hopkins and R. C. Deen, August 1983; also Geotechnical Testing Journal, American Society for Testing and Materials, March 1984.
- UKTRP-83-17 "Highway Skid Resistance," J. H. Havens, September 1983.
- UKTRP-83-18 "Child Safety Seat Usage in Kentucky after Enactment of a Mandatory Usage Law," K. R. Agent, September 1983.
- UKTRP-83-19 "Problem Identification for Highway Safety Plan (FY 1984)," J. G. Pigman and Tom Creasey, September 1983.
- UKTRP-83-20 "Low-Strength (Pozzolanic) Materials for Highway Construction," G. W. Sharpe, L. E. Epley, D. L. Allen, H. F. Southgate, and R. C. Deen, September 1983; also American Concrete Institute, Fall Convention, September 1983.
- UKTRP-83-21 "Structural Design and Installation Criteria for Rigid and Flexible Conduit," R. D. Hughes, September 1983.
- UKTRP-83-22 "Alcohol Impact Evaluation," J. G. Pigman and K. R. Agent, September 1983.
- UKTRP-83-23 "Survey of Guardrail End Treatment Usage," J. G. Pigman and K. R. Agent, October 1983.
- UKTRP-83-24 "Evaluation of Asphaltic Pavements for Overlay Design," R. C. Deen, H. F. Southgate, and G. W. Sharpe, October 1983; prepared for presentation to American Society for Testing and Materials Symposium on Pavement Maintenance and Rehabilitation, December 1983.
- UKTRP-83-25 "Development of Pavement Thickness Designs Using Pozzolanic Base Materials," G. W. Sharpe, H. F. Southgate, and R. C. Deen, October 1983.
- UKTRP-83-26 "Concrete Barrier Geometrics (US 41 Bridge in Henderson, Kentucky)," October 1983.

- UKTRP-83-27 "Performance Evaluation of Experimental Paint-Stripe Beads," K. R. Agent and J. G. Pigman, November 1983.
- UKTRP-84-1 "Rutting: A Case Study (US 23; 1.5 Miles North of Louisa)," J. H. Havens, G. W. Sharpe, D. L. Allen, and H. F. Southgate, January 1984.
- UKTRP-84-2 "A Field and Laboratory Compaction Study of a Mixture of Retorted and Raw Oil Shale from the Means Project in Montgomery County," D. L. Allen and Bobby Meade, January 1984.
- UKTRP-84-3 "Thickness Design Cruves for Portland Cement Concrete Pavements," H. F. Southgate and R. C. Deen, February 1984.
- UKTRP-84-4 "Periodic Nondestructive Evaluation of In-service Metal Bridges," Theodore Hopwood and R. C. Deen, March 1984; prepared for presentation to FCP Conference Review on Project 5K, Federal Highway Administration, March 21-22, 1984.
- UKTRP-84-5 "Traffic Accident Rates in Kentucky (1982)," K. R. Agent, March 1984.
- UKTRP-84-6 "Thickness Design Procedure for Portland Cement Concrete Pavements," H. F. Southgate and R. C. Deen, March 1984.
- UKTRP-84-7 "Specially Constructed Bridges: Activities for Fiscal Year 1983," Theodore Hopwood, J. H. Havens, and G. W. Sharpe, April 1984.
- UKTRP-84-8 "An Evaluation of Elastizell Concrete as a Lightweight Fill Material," D. L. Allen and B. W. Meade, April 1984.
- UKTRP-84-9 "Structural Evaluation of Asphaltic Pavements," R. C. Deen, H. F. Southgate, and G. W. Sharpe, April 1984; prepared for FHWA Workshop on Pavement Rehabilitation, Oklahoma City, OK, May 14-17, 1984.
- UKTRP-84-10 "Vanpool Demonstration Project," J. G. Pigman and K. R. Agent, April 1984.
- UKTRP-84-11 "Variations of Fatigue due to Unevenly Loaded Axles within Tridem Groups," H. F. Southgate and R. C. Deen, April 1984.
- UKTRP-84-12 "Variable Serviceability Concept for Pavement Design Confirmed by AASHO Road Test Fatigue Data," H. F. Southgate and R. C. Deen, April 1984.
- UKTRP-84-13 "Introduction to Cable Suspension Bridges," T. Hopwood and J. H. Havens, May 1984.
- UKTRP-84-14 "Corrosion of Cable Suspension Bridges," T. Hopwood and J. H. Havens, May 1984.

- UKTRP-84-15 "Inspection, Prevention, and Remedy of Suspension Bridge Cable Corrosion Problems," T. Hopwood and J. H. Havens, May 1984.
- UKTRP-84-16 "Analysis of Accidents Involving Breakaway-Cable-Terminal End Treatments," J. G. Pigman, K. R. Agent, and Tom Creasey, June 1984.
- UKTRP-84-17 "Analysis of Accidents Involving Crash Cushions," J. G. Pigman, K. R. Agent, and Tom Creasey, June 1984.
- UKTRP-84-18 "An Evaluation of Pavement Drainage, Interstate 64, Rowan-Carter Counties," D. L. Allen and H. F. Southgate, June 1984.
- UKTRP-84-19 "Survey of Effectiveness of Transportation Services (1984)," J. G. Pigman and K. R. Agent, June 1984.
- UKTRP-84-20 "Effectiveness of Traffic Noise Barrier on I 471 in Campbell County, Kentucky," Tom Creasey and K. R. Agent, June 1984.

PAPERS, FY 1984

J. G. Pigman and K. R. Agent, "Field Evaluation of Snowplowable Pavement Markers", Research Record 933, Transportation Research Board, 1983.

Theodore Hopwood and R. C. Deen, "Periodic Nondestructive Evaluation of In-service Metal Bridges", Proceedings, FCP Conference Review on Project 5K, Federal Highway Administration, March 1984.

R. C. Deen, H. F. Southgate, and G. W. Sharpe, "Structural Evaluations of Asphaltic Pavements", Proceedings, FHWA Workshop on Pavement Rehabilitation, May 1984.

PRESENTATIONS, FY 1984

J. G. Pigman; Ninth International Forum on Traffic Records Systems, "Impact Evaluation of Lexington-Fayette County Traffic Alcohol Program", Jul 18-21, 1983; St. Paul, MN.

G. W. Sharpe, L. E. Epley, D. L. Allen, H. F. Southgate, and R. C. Deen; American Concrete Institute Fall Convention, "Low-Strength (Pozzolanic) Materials For Highway Construction", Sep 25-30, 1983; Kansas City, MO.

Ted Hopwood; American Society of Nondestructive Testing Conference, Chaired the Highway Session, Oct 22, 1983; Dallas, TX.

G. W. Sharpe; American Society of Nondestructive Testing Qualtest II Conference, "Structural Evaluation of Pavements For Highways, Streets, and Airports", Oct 22, 1983; Dallas, TX.

H. F. Southgate; 37th Annual Ohio Transportation Engineering Conference, "Testing to Determine the Modulus of Fragmented Concrete", Nov 30, 1983; Columbus, OH.

R. C. Deen, H. F. Southgate, and G. W. Sharpe, American Society for Testing and Materials Symposium on Pavement Maintenance and Rehabilitation, "Evaluation of Asphaltic Concrete Pavements for Overlay Design", Dec 7, 1983; Bal Harbour, FL.

R. C. Deen, H. F. Southgate, and G. W. Sharpe; Twentieth Kentucky Concrete Conference, "Rigid Pavement Design: Development and Suggested Criteria", Jan 11, 1984; Lexington, KY.

G. W. Sharpe; Fifth Annual International Conference on Economic and Environmental Utilization of Kiln Dust and Kiln Dust/Fly Ash Technology, "Kentucky Evaluates N-Viro Crete", Feb 13-16, 1984; Perrysburg, OH.

Ted Hopwood and R. C. Deen; Federal Highway Administration Conference Review of Project 5K, "Periodic Nondestructive Evaluation of In-Service Metal Bridges", Mar 22, 1984; McLean, VA

H. F. Southgate; Annual Meeting of Michigan Asphalt Pavement Association, "Evaluation of Fragmenting and Seating of Portland Cement Concrete Pavements", Mar 29, 1984; Michigan State University, Lansing, MI.

R. C. Deen, H. F. Southgate, and G. W. Sharpe; Third Annual Kentucky Asphalt Conference, "Evaluation of Asphaltic Pavements for Overlay Design", Apr 5-6, 1984; Lexington, KY.

T. C. Hopkins; Fifth Annual Southeastern States Dam Safety Conference, "Stability Analysis of Embankments on Soft Clay Foundations", Apr 16-17, 1984; Knoxville, TN.

J. G. Pigman and K. R. Agent; Transportation Research Board "Impact Evaluation of Lexington-Fayette County Traffic Alcohol Program", Jan 16-20, 1984; Washington, D.C.

J. G. Pigman; Transportation Research Board "Survey Of Governor's Highway Safety Representatives and Coordinators", Jan 16-20, 1984; Washington, D.C.

AWARDS, FY 1984

Triangle Service Key (from Triangle Fraternity) to R. C. Deen for pre-eminent work in developing the national organization of the fraternity, Aug 13, 1983.

TRAINING, FY 1984

Ted Hopwood, Krautkrammer-Branson Level I (ASNT) Ultrasonic Course; Jul 11-15, 1983; Charlotte, NC

Ted Hopwood, Krautkrammer-Branson Level II (ASNT) Ultrasonic Course; Jul 18-22, 1983; Charlotte, NC

R. C. Deen, Surface Subsidence Caused by Underground Mining; Institute of Mining and Minerals Research, Aug 25-26, 1983; Lexington, KY

Nancy Bratton, Professional Development for Executive Secretaries and Administrative Assistants; University of Wisconsin - Eau Claire, Sep 15-16, 1983; Lexington, KY

Nancy Bratton, Recognizing and Reinforcing Good Performance; University of Kentucky, Feb 9, 1984; Lexington, KY

Nancy Bratton, The Supervisor's Role in New Employee Orientation; University of Kentucky, Feb 16, 1984; Lexington, KY

Nancy Bratton, Documenting and Correcting Disciplinary Problems (legal aspects); University of Kentucky, Mar 22, 1984; Lexington, KY

Nancy Bratton, Correcting Employee Mistakes; University of Kentucky, Mar 1, 1984; Lexington, KY

Nancy Bratton, Interviewing and Selecting New Employees; University of Kentucky, Apr 11-13, 1984; Lexington, KY

Ted Hopwood, Westinghouse NDE Technical Institute, Radiographic Film Interpretation, Apr 30 - May 4, 1984; Pittsburg, PA

Ted Hopwood, Sperry School for NDE, Eddy Current and Data Interpretation, Jun 4-8, 1984; Columbus, OH

K. R. Agent and J. G. Pigman, Functional Requirements of Highway Safety Features; Federal Highway Administration, Jan 25-27, 1984; Frankfort, KY

ADDITIONAL MEETINGS, FY 1984

G. W. Sharpe, Third International Conference on Low-Volume Roads, Jul 24-28, 1983; Tempe, AZ

K. R. Agent, R. C. Deen, J. G. Pigman, G. W. Sharpe, and H. F. Southgate, Annual Meeting of the Transportation Research Board, Jan 16-20, 1984; Washington, DC

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

R. C. Deen, Member

American Society of Civil Engineers

D. L. Allen, Member.

D. L. Allen, Program Chairman, Kentucky Geotechnical Engineering Group.

R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group.

J. H. Havens, Member.

T. C. Hopkins, Member.

T. C. Hopkins, Member, Kentucky Geotechnical Engineering Group.

American Society for Testing and Materials

R. C. Deen, Chairman, Committee on Publication.

R. C. Deen, First Vice-Chairman, Committee on Soil and Rock (D-18).

R. C. Deen, Chairman, Editorial Subcommittee of Committee on Soil and Rock (D-18).

R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18).

R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18).

R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18).

Institute of Transportation Engineers

K. R. Agent, Co-chairman, 1984 Technical Workshop, Kentucky Division, Southern Section.

K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee.

J. G. Pigman, Member, Influence of Vehicle Design and Operating Characteristics on Roadway Design Committee.

J. G. Pigman, Co-chairman, 1984 Technical Workshop, Kentucky Division, Southern Section.

R. C. Deen, Member.

G. W. Sharpe, Member.

Kentucky Society of Professional Engineers

D. L. Allen, Member.

R. C. Deen, Member, Chairman of History Committee.

J. H. Havens, Member.

J. G. Pigman, Member.

J. G. Pigman, Secretary, Bluegrass Chapter.

T. C. Hopkins, Member.

H. F. Southgate, Member.

G. W. Sharpe, Member.

Transportation Research Board

- K. R. Agent, Member, Instrumentation Principles and Applications Committee.
- R. C. Deen, Chairman, Group 2 Council, Design and Construction of Transportation Facilities.
- R. C. Deen, Member, Chemical Stabilization Committee.
- R. C. Deen, Member, Earthwork Construction Committee.
- R. C. Deen, Member, Engineering Geology Committee.
- J. G. Pigman, Member, Methology for Evaluating Highway Improvements Committee.
- J. G. Pigman, Chairman, Subcommittee on State Program Management.
- J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee.
- G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavement Sections.
- H. F. Southgate, Member, Flexible Pavement Design Committee.
- H. F. Southgate, Member, Pavement Evaluation Committee.
- G. W. Sharpe, Member, Rigid Pavement Committee.

Others

- H. F. Southgate, Member, The Association of Asphalt Paving Technologists.
- J. H. Havens, Member, The Association of Asphalt Paving Technologists.
- T. Hopwood, Member, American Welding Society.
- T. Hopwood, Member, American Society for Metals.
- T. Hopwood, Member, American Society for Nondestructive Testing.
- G. W. Sharpe, Member, Controlled Low-Strength Materials Committee, American Concrete Institute.

International Society of Soil Mechanics and Foundation Engineers

- T. C. Hopkins, Member.
- R. C. Deen, Member.

**SUMMARY OF ACTIVITIES
FISCAL YEAR 1985**

Annual Summary, FY 1985

The Kentucky Transportation Research Program completed its fourth full year as a department within the University of Kentucky College of Engineering in a positive manner. Fiscal Year 1985 saw an increase in the research program for the Transportation Cabinet; additional studies were approved along with an increased budget above the Fiscal 1984 level.

Later in the fiscal year, other studies were proposed and approved for inclusion in the Transportation Cabinet's research program. Procedures were developed to provide for quick response to requests for short-term studies requiring immediate attention. In addition, a system was developed to provide for long-term monitoring of select Transportation Cabinet projects containing experimental features. Another new study involves development of models and strategies for use in pavement management in Kentucky. A fourth study involves the evaluation of performance of guardrail end treatments.

Four Federal-Aid Research Tasks and three Experimental Projects were proposed and approved for Federal Highway Administration funding. Federal Task Order 8 involving use of an acoustical emission device for in-process weld monitoring was awarded to KTRP. Additional research studies were conducted for American Engineering Inc., Scientific Measurement Systems, Kentucky State Police, and the Lexington-Fayette Urban County Government. Approximately \$1.4 million was granted for studies conducted during FY 1985.

Studies undertaken covered a broad range of areas within the transportation discipline. Thirty-one major reports were issued during the year. Eight papers were presented at various national and international conferences and the Transportation Research Board. Geotechnical studies included soil-bridge abutment interaction; slope stability analyses; fill-height tabulations for pipe, pipe-arch, and arch culverts; and engineering properties and uses of Kentucky shales. Studies in the materials performance area included evaluation of experimental pavement surfaces, special problems of metal bridges, evaluation of sandstone bases and surfaces, evaluation of procedures for testing aggregates, stability of asphaltic concrete mixtures, and native aggregates for skid resistance. Traffic and safety studies involved determination of average accident rates in Kentucky, effectiveness of noise barriers, and evaluations of various roadway delineation techniques. Several other studies dealt with development of pavement design methodologies and analyses of pavement and shoulder performances.

The value of studies that were ongoing or finalized in Fiscal 1985 has been evidenced through widespread implementation of recommendations presented in interim or final reports issued for Transportation Cabinet studies. The Division of Design is preparing a Standard Drawing for a recommended guardrail end treatment. The Division of Bridges has modified design guidelines for piles and culverts as a result of findings from two separate studies. Approximately one-half million snowplowable and recessed pavement markers have been installed recently on Kentucky roadways in accordance with suggestions presented in an interim report. A Special Provision has been issued that designates compaction for embankments composed of shales conforming to procedures developed under a recently completed study.

The Division of Planning has revised procedures for use in estimating equivalent axleloads. Revised procedures conform to guidelines established under a study to be completed soon. Thermoplastic stripping materials are now used routinely on open-graded friction courses for surfaces on interstate and many primary resurfacing projects. Principal investigators identified the thermoplastics as being more durable and cost effective. The Division of Materials will incorporate an elastic modulus requirement for asphaltic concrete mixtures in accordance with findings presented in an interim report. Overlay designs for many reconstruction projects are based upon results of work conducted under several studies.

Nondestructive test procedures for bridge inspection and evaluation have been developed and demonstrated under a task order and an on-going study. Recommendations based upon results of such tests have been implemented. The Department of Highways has recently computerized the bid section of bid proposals as a result of a program developed by KTRP investigators. Requirements for periodic washing of galvanized steel structures, more thorough inspection of masonry coating applications, and multiple tests for certain aggregates have resulted from various study recommendations.

The Research Program was conducted by a team of 15 research engineers and 26 technicians and support staff. Thirteen undergraduate students and two graduate students were employed on a part-time basis. Engineers were active in professional organizations and various training programs throughout the year to keep abreast of rapidly changing technology and management and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees.

Staff members are frequently called upon to share their expertise with organizations outside the Program. Three presentations were made at the 1985 annual meeting of the Transportation Research Board in Washington, D.C. Thirty-five other presentations were made to such organizations as the Plantmix Industry of Kentucky, Kentucky Occupant Restraint Conference, American Society of Criminology, American Public Works Association, North American Pavement Management Conference, National Highway Traffic Safety Administration Regional Alcohol Conference, and the American Association of State Highway and Transportation Officials. Various short courses, symposiums, and workshops were administered and taught by staff members. One engineer also served as a part-time instructor in UK's College of Engineering.

REPORTS PUBLISHED, FY 1985

- UKTRP-84-21 "Evaluation of Full-Depth Asphaltic Concrete Pavement," H. F. Southgate, G. W. Sharpe, Mark Anderson, and R. C. Deen, July 1984.
- UKTRP-84-22 "Analysis of Loads and Settlements for Reinforced Concrete Culverts," D. L. Allen and B. W. Meade, August 1984.
- UKTRP-84-23 "Pavement Thickness Designs Utilizing Low-Strength (Pozzolanic) Base and Subbase Materials," G. W. Sharpe, R. C. Deen, H. F. Southgate, and Mark Anderson, August 1984.
- UKTRP-84-24 "Relationship between Kentucky CBR and Slake Durability," T. C. Hopkins, August 1984.
- UKTRP-84-25 "Impact Evaluation of Traffic Alcohol Programs: Selected Locations in Kentucky," J. G. Pigman and K. R. Agent, September 1984 (for Annual Meeting of American Society of Criminology, Cincinnati, OH, November 7-11, 1984).
- UKTRP-84-26 "Nondestructive Evaluation of Rigid Pavements Using Road Rater Deflections," G. W. Sharpe, Mark Anderson, R. C. Deen, and H. F. Southgate, September 1984 (for International Conference on Concrete Pavement Design, West Lafayette, IN, April 23-25, 1985).
- UKTRP-84-27 "1984 Safety Belt and Child Safety Seat Usage Rates in Kentucky and Evaluation of a Public Information Campaign," K. R. Agent and J. M. Salsman, September 1984.
- UKTRP-84-28 "Jackson Purchase Parkway Pavement Study," J. H. Havens, October 1984.
- UKTRP-84-29 "Water-Induced Surface Failures on I 65, Hardin County, Kentucky," E. G. Williams, H. F. Southgate, and R. C. Deen, October 1984.
- UKTRP-84-30 "Estimation of Equivalent Axleloads: Computer Program Documentation," J. M. Salsman and J. A. Deacon, October 1984.
- UKTRP-84-31 "Evaluation of Durable Lane Delineation Materials," K. R. Agent and J. G. Pigman, December 1984.
- UKTRP-84-32 "Evaluation of Durable Crossbar and Stopbar Marking Materials," K. R. Agent and J. G. Pigman, December 1984.
- UKTRP-84-33 "A Review and Analysis of Pile Design," D. L. Allen, December 1984.
- UKTRP-84-34 "Pavement Management in Kentucky," G. W. Sharpe, R. C. Deen, H. F. Southgate, R. L. Rizenbergs, and J. L. Burchett, December 1984 (for North American Pavement Management Conference, Toronto, Canada, March 18-21, 1985).

- UKTRP-85-1 "Laboratory Evaluations of Stabilized Flue Gas Desulfurization Sludge (Scrubber Sludge) and Aggregate Mixtures," Mark Anderson, G. W. Sharpe, D. L. Allen, H. F. Southgate, and R. C. Deen, January 1985 (for International Ash Utilization Symposium/Exposition, Orlando, Fl, March 4-7, 1985).
- UKTRP-85-2 "Traffic Accident Rates in Kentucky (1983)," J. M. Salsman and K. R. Agent, January 1985.
- UKTRP-85-3 "Evaluation of Truck Escape Ramps," J. G. Pigman and K. R. Agent, January 1985.
- UKTRP-85-4 "Comparison of Contained Rock Asphalt Mat (CRAM) with Conventional Asphaltic Concrete Pavements," H. F. Southgate, January 1985.
- UKTRP-85-5 "Strain Gage Installation on the I-75 Bridge at Covington, Kentucky, and Subsequent Data Analysis," T. Hopwood and J. G. Mayes, January 1985.
- UKTRP-85-6 "Development of Accident Reduction Factors," T. Creasey and K. R. Agent, March 1985.
- UKTRP-85-7 "Fly Ash Stabilized Bases in Kentucky," G. W. Sharpe and L. Epley, March 1985 (for Seminar on Fly Ash Utilization in Highway Construction, Atlanta, Ga, March 12-13, 1985).
- UKTRP-85-8 "Truck Design and Usage Related to Highway Pavement Performance," R. C. Deen, H. F. Southgate, G. W. Sharpe, D. L. Allen, and J. G. Pigman, March 1985.
- UKTRP-85-9 "Unstable Subgrade, I 65, Hardin County," T. C. Hopkins and G. W. Sharpe, March 1985.
- UKTRP-85-10 "Analysis of Movements and Forces on Bridge Approaches: A Case Study (Bridge over Chesapeake Avenue on Interstate 71 in Campbell County, Kentucky)," D. L. Allen, B. W. Meade, and T. C. Hopkins, April 1985.
- UKTRP-85-11 "Structural Evaluation of Asphaltic Pavements," R. C. Deen, H. F. Southgate, and G. W. Sharpe, April 1985 (Same as UKTRP-84-9) (for Workshop on Pavement Rehabilitation, Albany, NY, April 2-4, 1985).
- UKTRP-85-12 "Long-Term Movements of Highway Bridge Approach Embankments and Pavements," T. C. Hopkins, April 1985.
- UKTRP-85-13 "Effects of Load Distributions and Axle and Tire Configurations on Pavement Fatigue," H. F. Southgate and R. C. Deen, May 1985 (for Second International Conference on Weigh-In-Motion, Atlanta, Ga, May 20-24, 1985).

- UKTRP-85-14 "Feasibility of Computerization of the Bid Item Section of Bid Proposals," J. G. Mayes and M. Isenhour, May 1985.
- UKTRP-85-15 "Effectiveness of Traffic Noise Barrier on I 471 in Campbell County, Kentucky," Tom Creasey and K. R. Agent, May 1985.
- UKTRP-85-16 "Summary Report of Ranking Methodologies," R. C. Deen, May 1985 (for North American Pavement Management Conference, Toronto, Canada, March 18-21, 1985).
- UKTRP-85-17 "Sampling Techniques for the Collection of Vehicle Classification Data," J. G. Pigman, June 1985.

PAPERS, FY 1985

J. G. Pigman and K. R. Agent, "Impact Evaluation of Lexington-Fayette County Traffic Alcohol Program," Research Record 974, Transportation Research Board, 1984.

K. R. Agent, "State of the Practice: Environmental Noise Measurements," Research Circular 288, Transportation Research Board, February 1985.

G. W. Sharpe, R. C. Deen, H. F. Southgate, R. L. Rizenbergs, and J. L. Burchett, "Pavement Management in Kentucky," Proceedings, Vol 2, North American Pavement Management Conference, Toronto, Ontario, Canada, 1985.

R. C. Deen, "Summary Report on Ranking Methodologies," Proceedings, Vol 3, North American Pavement Management Conference, Toronto, Ontario, Canada, 1985.

M. Anderson, G. W. Sharpe, D. L. Allen, H. F. Southgate, and R. C. Deen, Seventh International Ash Utilization Symposium/Exposition, "Laboratory Evaluations of Stabilized Flue Gas Desulfurization Sludge (Scrubber Sludge) and Aggregate Mixtures," March 4-7, 1985; Orlando, FL

R. C. Deen, H. F. Southgate, and G. W. Sharpe, "Structural Evaluation of Asphaltic Pavements," Workshop on Pavement Rehabilitation, April 2-4, 1985, Albany, NY

G. W. Sharpe, M. Anderson, R. C. Deen, and H. F. Southgate, Third International Conference on Concrete Pavement Design, "Nondestructive Evaluation of Rigid Pavements Using Road Rater Deflections," April 23-25, 1985; Purdue University, West Lafayette, IN

K. R. Agent and J. G. Pigman, "Evaluation of Durable Lane Delineation Materials," ROADS AND BRIDGES, May 1985.

K. R. Agent, "Determining Vehicle Change Intervals," Technical Committee 4A-16, ITE Journal, Institute of Transportation Engineers, May 1985.

K. R. Agent, "Use and Timing of Signal Change Intervals Recommended Practice," Institute of Transportation Engineers, Technical Committee 4A-16.

PRESENTATIONS, FY 1985

H. F. Southgate, Visitations for purpose of making presentations and receiving training (exchange of technology) in following subject areas at following organizations, June 25-September 7, 1984

Topics:	Soil and rock mechanics
	Asphaltic concrete mixtures -- problems and testing
	Traffic data -- axleloads, traffic classifier equipment, weigh-in-motion equipment
	Pavement design -- dynamic deflections, test track
	Pavement management in developing countries
	Profilometer data

Photologging
 Train scheduling
 Vehicle crash testing

Organizations: Bundesanstalt fur Strassenwesen: Koln, West Germany
 Dracos (Consulting Engineers): Lugano, Switzerland
 Lausanne Institute of Technology: Lausanne,
 Switzerland
 Organization of Economic Development Commission
 (Highway Transportation Committee): Paris, France
 T. P. O'Sullivan & Partners: London, England
 Transportation Road Research Laboratory: Crowthorne,
 England
 University of Nottingham: Nottingham, England
 Zurich Institute of Technology: Zurich, Switzerland

G. W. Sharpe, Workshop for Northern Kentucky Area Development District and Northern Kentucky Public Works Association, "Snow and Ice Control" and "Cracking Sealing of Pavements," July 12, 1984; Florence, KY

R. C. Deen, Midyear Meeting of the Plantmix Asphalt Industry of Kentucky, "Recent and Current Research Related to Asphaltic Materials and Components in Transportation Facilities," July 13, 1984; Lexington, KY

K. R. Agent, Kentucky Occupant Restraint Conference, "Evaluation of Loaner Programs," July 31-August 2, 1984; Lexington, KY

R. C. Deen, Eleventh Joint Transportation Research Managers' Workshop, "Highlights of Transportation Research in Kentucky," August 21-23, 1984; Charleston, SC

J. G. Pigman, Annual Meeting of American Society of Criminology, "Impact Evaluation of Traffic Alcohol Programs: Selected Locations in Kentucky," November 7-11, 1984; Cincinnati, OH

H. F. Southgate, Workshop for Woodford County Road Department, "Snow and Ice Control," "Pothole Repair," and "Overlay Construction," December 10, 1984; Versailles, KY

T. Hopwood, Demonstration for State Highway Personnel from FHWA Regions 1 and 3, Sponsored by FHWA, "Gard Acoustic Emission Weld Monitor," January 7-11, 1985; Lancaster, PA

J. G. Pigman, Annual Meeting of Transportation Research Board, "Analysis of Accidents Involving Breakaway-Cable Terminal End Treatments," January 14-17, 1985; Washington, DC

K. R. Agent, Annual Meeting of Transportation Research Board, "Analysis of Accidents Involving Crash Cushions," January 14-17, 1985; Washington, DC

G. W. Sharpe, R. C. Deen, H. F. Southgate, and M. Anderson, Annual Meeting of Transportation Research Board, "Pavement Thickness Designs Utilizing Low-Strength (Pozzolanic) Base and Subbase Materials," January 14-17, 1985; Washington, DC

T. Hopwood, Committee on Fabrication and Inspection, Annual Meeting of Transportation Research Board, "Acoustic Emission Weld Monitoring," January 15, 1985; Washington, DC

H. F. Southgate, "Workshop on Pavement Evaluation and Overlay Design," Sponsored by FHWA and Maine DOT

January 22, 1985; Bangor, Me -- Operational Personnel, Maine DOT

January 23, 1985; Augusta, Me -- Administrative Personnel, Maine DOT

January 24-25, 1985; Augusta, Me -- Planning and Design Engineers from Maine, New Hampshire, Vermont

H. F. Southgate, "Effects of Axleloads" and "Analysis of Road Rater Deflection Tests," Workshop sponsored by Orange County, California, and LaBelle Consultants, February 8, 1985, Santa Ana, CA

K. R. Agent, "Seatbelt Research," 3-minute research brief broadcast over WBKY on February 11 and 12, 1985

T. Hopwood, Quality Assurance Workshop, FHWA Region 3, "Acoustic Emission Weld Monitoring," February 13, 1985; Morgantown, WV

H. F. Southgate, 28th Annual Alabama Highway Engineering and Construction Conference/Exposition, "Breaking and Seating of Portland Cement Concrete Pavements," February 13-14, 1985; Montgomery, AL

J. H. Havens, coordinator for clinic on "On-the-Job Safety in Public Works," American Public Works Association, February 25, 1985, Lexington, KY

M. Anderson, G. W. Sharpe, D. L. Allen, H. F. Southgate, and R. C. Deen, Seventh International Ash Utilization Symposium/Exposition, "Laboratory Evaluations of Stabilized Flue Gas Desulfurization Sludge (Scrubber Sludge) and Aggregate Mixtures," March 4-7, 1985; Orlando, FL

T. Hopwood, Demonstration for State Highway Personnel from FHWA Region 4, Sponsored by FHWA, "GARD Acoustic Emission Weld Monitor," March 7-8, 1985; Augusta Iron & Steel Co, Augusta, GA

G. W. Sharpe and L. E. Epley, "Fly Ash Stabilized Bases in Kentucky," FHWA Seminar on Fly Ash Utilization in Highway Construction, March 12-13, 1985; Atlanta, GA

R. C. Deen, short course presented for the Institute for Mining and Minerals Research, "Fundamentals of Geotechnical Engineering," March 13-14, 1985, Lexington, KY

G. W. Sharpe, R. C. Deen, H. F. Southgate, R. L. Rizenbergs, and J. L. Burchett, North American Pavement Management Conference, "Pavement Management in Kentucky," March 18-21, 1985; Toronto, Ontario, Canada

R. C. Deen, North American Pavement Management Conference, "Ranking Methodologies," March 18-21, 1985; Toronto, Ontario, Canada

K. R. Agent, Annual Technical Meeting, Kentucky Division Southern Section Institute of Transportation Engineers, "A Proposed Recommended Practice for Determining Vehicle Change Intervals," March 26, 1985; Lexington, KY

T. Hopwood, Demonstration for State Highway Personnel from FHWA Region 5, Sponsored by FHWA, "GARD Acoustic Emission Weld Monitor," March 27-28, 1985; Phoenix Steel Corp, Eau Claire, WI

D. L. Allen, Pothole Repair Techniques, Workshop, April 2, 1985; Hopkinsville, KY

H. F. Southgate, Triregional Workshop on Pavement Rehabilitation, "Pavement Evaluation and Overlay Design," April 2-4, 1985, Federal Highway Administration, Albany, NY

G. W. Sharpe, Asphalt and Pavement Maintenance and Rehabilitation, Workshop, April 15; Owensboro, KY and April 17; Lexington, KY

G. W. Sharpe, M. Anderson, R. C. Deen, and H. F. Southgate, Third International Conference on Concrete Pavement Design, "Nondestructive Evaluation of Rigid Pavements Using Road Rater Deflections," April 23-25, 1985; Purdue University, West Lafayette, IN

J. G. Pigman, National Highway Traffic Safety Administration Regional Alcohol Conference, "Program Goals and Measures of Success for Community-Based DUI Programs," April 23-25, 1985; Lexington, KY

T. Hopwood, American Association of State Highway and Transportation Officials, "Acoustic Emission Monitoring of Welds," April 25, 1985; San Francisco, CA

H. F. Southgate and R. C. Deen, International Conference on Weigh-In Motion, "Effects of Load Distributions and Axle and Tire Configurations on Pavement Fatigue," May 20-24, 1985, Atlanta, GA

R. C. Deen, a short course presented for the Institute for Mining and Minerals Research, "Engineering Uses of Geosynthetic Fabrics," May 22-24, 1985; Lexington, KY

T. Hopwood, American Association of State Highway and Transportation Officials, "Acoustic Emission Monitoring of Welds," May 30, 1985; Nashville, TN

TRAINING, FY 1985

R. C. Deen, Pavement Management Seminar for College Faculty, The University of Texas at Austin, August 6-17, 1984; Austin, TX

T. C. Hopkins and R. C. Deen, Geotextile Engineering, National Highway Institute, September 10-13, 1984; Frankfort, KY

D. L. Allen, R. C. Deen, and T. C. Hopkins, Drilled Foundation Seminar, Association of Drilled Foundation Contractors, February 27-28, 1985; Fort Mitchell, KY

G. W. Sharpe and L. E. Epley, "Fly Ash Stabilized Bases in Kentucky," FHWA Seminar on Fly Ash Utilization in Highway Construction, March 12-13, 1985; Atlanta, GA

T. Hopwood, Fracture Mechanics and Damage Tolerance, American Society for Metals, March 19-22, 1985; Cleveland, OH

D. L. Allen and G. W. Sharpe, Pavement Rehabilitation Workshop, National Highway Institute, March 26-29, 1985; Frankfort, KY

MEETINGS, FY 1985

G. W. Sharpe, International Conference on In Situ Nondestructive Testing of Concrete, October 1-4, 1984; Ottawa, Ontario, Canada

T. Hopwood, Qualtest III Conference (Chairman of Highway Session), October 4, 1984; Cincinnati, OH

G. W. Sharpe, Annual Meeting of American Concrete Institute, October 28-November 2, 1984; New York, NY

D. L. Allen, M. Anderson, D. W. Armour, R. C. Deen, T. C. Hopkins, and H. F. Southgate, Ohio River Valley Soils Seminar -- Practical Applications of Drainage in Geotechnical Engineering, November 1984; Fort Mitchell, KY

K. R. Agent, M. Anderson, T. Creasey, J. H. Havens, T. Hopwood, J. G. Pigman, G. W. Sharpe, and H. F. Southgate, Annual Meeting of Transportation Research Board, January 14-17, 1985; Washington, DC

R. C. Deen, Chairman and Summary Reporter, Future Directions Workshop, North American Pavement Management Conference, March 17-21, 1985; Toronto, Ontario, Canada

K. R. Agent, T. Creasey, R. C. Deen, and J. G. Pigman, Annual Technical Meeting, Kentucky Division Southern Section Institute of Transportation Engineers, March 26, 1985; Lexington, KY

R. C. Deen, American Society for Testing and Materials, Committee on Soil and Rock, June 23-26, 1985; Los Angeles, CA

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

- R. C. Deen, Member.
- J. H. Havens, Vice President, Kentucky Chapter.

American Society of Civil Engineers

- D. L. Allen, Member.
- D. L. Allen, Chairman ORVSS XVI, Kentucky Geotechnical Engineering Group.
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group.
- J. H. Havens, Member.
- T. C. Hopkins, Member.
- T. C. Hopkins, Member, Kentucky Geotechnical Engineering Group.

American Society for Testing and Materials

- R. C. Deen, Chairman, Committee on Publication.
- R. C. Deen, First Vice-Chairman, Committee on Soil and Rock (D-18).
- R. C. Deen, Chairman, Editorial Subcommittee of Committee on Soil and Rock (D-18).
- R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18).
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18).
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18).

Institute of Transportation Engineers

- K. R. Agent, Co-chairman, 1984 Technical Workshop, Kentucky Division, Southern Section.
- K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee.
- K. R. Agent, Member, Warrants for Left-Turn Storage Lanes Committee.
- J. G. Pigman, Member, Influence of Vehicle Design and Operating Characteristics on Roadway Design Committee.
- J. G. Pigman, Co-chairman, 1984 Technical Workshop, Kentucky Division, Southern Section.
- R. C. Deen, Member.
- G. W. Sharpe, Member.

Kentucky Society of Professional Engineers

- D. L. Allen, Member.
- R. C. Deen, Member, Chairman of History Committee.
- J. H. Havens, Member.
- J. G. Pigman, Member.
- J. G. Pigman, Secretary, Bluegrass Chapter.
- T. C. Hopkins, Member.
- H. F. Southgate, Member.
- G. W. Sharpe, Member.
- D. Q. Hunsucker, Member.

Transportation Research Board

- K. R. Agent, Member, Instrumentation Principles and Applications Committee.
- R. C. Deen, Chairman, Group 2 Council, Design and Construction of Transportation Facilities.
- R. C. Deen, Member, Chemical Stabilization Committee.
- R. C. Deen, Member, Earthwork Construction Committee.
- R. C. Deen, Member, Engineering Geology Committee.
- J. G. Pigman, Member, Methodology for Evaluating Highway Improvements Committee.
- J. G. Pigman, Chairman, Subcommittee on State Program Management.
- J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee.
- G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavement Sections.
- H. F. Southgate, Member, Flexible Pavement Design Committee.
- H. F. Southgate, Member, Pavement Evaluation Committee.
- G. W. Sharpe, Member, Rigid Pavement Committee.

Others

- H. F. Southgate, Member, The Association of Asphalt Paving Technologists.
- J. H. Havens, Member, The Association of Asphalt Paving Technologists.
- T. Hopwood, Member, American Welding Society.
- T. Hopwood, Member, American Society for Metals.
- T. Hopwood, Member, American Society for Nondestructive Testing.
- G. W. Sharpe, Member, Controlled Low-Strength Materials Committee, American Concrete Institute.

International Society of Soil Mechanics and Foundation Engineers

- T. C. Hopkins, Member.
- R. C. Deen, Member.

Kentucky Association of Transportation Engineers

- J. H. Havens, Member.
- R. C. Deen, Member.

Professional Women's Forum

- Nancy Bratton, Member, Scholarship Committee.

**SUMMARY OF ACTIVITIES
FISCAL YEAR 1986**

Annual Summary, FY 1986

The Kentucky Transportation Research Program completed its fifth full year as a department within the University of Kentucky College of Engineering in a positive manner. Fiscal Year 1986 saw an increase in the research program for the Transportation Cabinet; additional studies were approved along with an increased budget above the Fiscal 1985 level.

Later in the fiscal year, other studies were proposed and approved for inclusion in the Transportation Cabinet's research program. Procedures were continued to provide for quick response to requests for short-term studies requiring immediate attention. Those type studies are designated State Highway Quick Response Studies. In addition, Kentucky Highway Investigative Tasks, which are 100-percent state funded, were continued.

During the year two new five-year studies were established: (1) Evaluation of Transportation Facilities for Earthquake Hazard Mitigation and (2) Utilization of Waste Materials. A mechanism was developed for employment of engineering students within KTRP with indirect costs for salaries being waived.

Six Federal-Aid Research Tasks, one Demonstration Project, and two Task Orders were proposed and approved for Federal Highway Administration funding. Three Kentucky Highway Investigative Tasks and four State Highway Quick Response Studies were proposed and approved for Transportation Cabinet funding. Additional research studies were conducted for American Engineering Inc., Oravo Lime, Inc., Kentucky State Police, and the Lexington-Fayette Urban County Government. Approximately \$1.4 million was granted for studies conducted during FY 1986.

Studies undertaken covered a broad range of areas within the transportation discipline. Thirty-one major reports were issued during the year. Seven papers were presented at various conferences and the Transportation Research Board. Geotechnical studies included soil-bridge abutment interaction; fill-height tabulations for pipe, pipe-arch, and arch culverts; engineering properties and uses of Kentucky shales; evaluation of embankment foundations stabilized with stone columns; evaluation of abutment foundations stabilized with stone columns and wick drain stabilization of approach fill foundations; and highway box culverts. Studies in the materials performance area included evaluation and correlation of properties of pavement components; evaluation of experimental pavement surfaces; performance monitoring of tieback walls; pozzolanic materials; evaluation of experimental bridge decks; special problems of metal bridges; evaluation of sandstone bases and surfaces; evaluation of procedures for testing aggregates; stability of asphaltic concrete mixtures; and native aggregates for skid resistance. Traffic and safety studies involved determination of average accidents rates in Kentucky; effectiveness of noise barriers; evaluations of various roadway delineation techniques; evaluation and performance of guardrail end treatments; traffic volume estimates and growth trends; traffic control in construction and maintenance zones; sampling of vehicle classification data; traffic control and accidents at rural high-speed intersections; accident reconstruction; and traffic trends and their relationship to highway user revenues. Several other studies dealt with development of pavement design methodologies; analyses of pavement and shoulder performances; pavement management in

Kentucky; pavement management for Lexington-Fayette Urban County Government; evaluation of bridge performance for construction and maintenance; and multi state study traffic forecasting for pavement design and analysis.

The value of studies that were ongoing or finalized in Fiscal Year 1986 has been evidenced through widespread implementation of recommendations presented in interim or final reports issued for Transportation Cabinet studies. A number of pavement designs have been developed using modulus values obtained from KTRP research. Design standards on subgrade stabilization on the Ashland-Alexandria highway were changed from portland cement stabilized soil to a lime stabilized soil based upon KTRP recommendations. Embankments on the Irvine-Beattyville road are being constructed using recommended specifications based upon results of research. Studies provided weight-distance tax information for recent legislative decisions on truck taxes. The Division of Planning has revised procedures for use in estimating equivalent axleloads and has requested additional information.

An evaluation of roadway delineation techniques has resulted in several recommendations being implemented by the Transportation Cabinet. An increased use of alkyd-resin extruded thermoplastic material for stop bars and cross walks was recommended and a contract has been awarded to use this material in the Louisville and Lexington areas. Two contracts have been awarded to use polyester paint for durable lane markings as a result of a KTRP study. Contracts also have been awarded for use of extruded thermoplastic material on open-graded asphalts on several interstates in Kentucky as a direct result of this research.

Another study on evaluation of construction zone marking materials was used to determine an approved list of such materials in construction projects in Kentucky. Guidelines developed by KTRP for use of permissive left-turn phasing have been incorporated into the Division of Traffic Guidance Manual. Also, the Transportation Cabinet is using the results of an evaluation of a traffic noise barrier in public meetings to illustrate the potential effectiveness of proposed noise barriers.

The Research Program was conducted by a team of 14 research engineers and 18 technicians and support staff. Fourteen undergraduate students and two graduate students were employed on a part-time basis. Engineers were active in professional organizations and various training programs throughout the year to keep abreast of rapidly changing technology and management and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees.

Staff members frequently are called upon to share their expertise with organizations outside the Program. Three presentations were made at the 1986 annual meeting of the Transportation Research Board in Washington, D.C. Seventeen other presentations were made to various other organizations. Various short courses, symposiums, and workshops were administered and taught by staff members. One engineer also served as a part-time instructor in UK's College of Engineering (Department of Civil Engineering).

REPORTS PUBLISHED, FY 1986

- UKTRP-85-18 "Problem Identification for Highway Safety Plan (FY 1986)," J. G. Pigman and K. R. Agent, July 1985.
- UKTRP-85-19 "Guidelines for the Use of Protected/Permissive Left-Turn Phasing," K. R. Agent, August 1985.
- UKTRP-85-20 "Traffic Trends and Their Relationship to Highway-User Revenues," J. G. Pigman and M. Vaziri, September 1985.
- UKTRP-85-21 "1985 Safety Belt and Child Safety Seat Usage Rates in Kentucky and Evaluation of a Public Information Campaign," K. R. Agent, September 1985.
- UKTRP-85-22 "Latex-Concrete Overlays on Bridge Decks (I 64, MP 150 to West Virginia Line)," J. H. Havens and Theodore Hopwood, September 1985.
- UKTRP-85-23 "Demonstration and Preliminary Evaluation of the Acoustic Emission Weld Monitor," Theodore Hopwood and R. C. Deen, September 1985.
- UKTRP-85-24 "Evaluation of Construction Zone Pavement Marking Materials," K. R. Agent and J. G. Pigman, September 1985.
- UKTRP-85-25 "A Survey of the States on Problems Related to Bridge Approaches," D. L. Allen, October 1985.
- UKTRP-85-26 "Impact Evaluation of the Traffic Alcohol Program in Lexington, Kentucky," J. G. Pigman and K. R. Agent, October 1985.
- UKTRP-85-27 "Evaluation of Stone Column Stabilized Embankment Foundation," B. W. Meade and D. L. Allen, November 1985.
- UKTRP-85-28 "Suggested Changes to Kentucky Statutes (Vehicle Weights and Dimensions)," H. F. Southgate and R. C. Deen, November 1985.
- UKTRP-85-29 "Jefferson Freeway Investigation," H. F. Southgate, G. W. Sharpe, T. Hopwood, J. H. Havens, M. Anderson, D. Q. Hunsucker, and R. C. Deen, November 1985.
- UKTRP-85-30 "Estimation of Equivalent Axleloads," J. A. Deacon and J. G. Pigman, December 1985.
- UKTRP-85-31 "A Computerized Analysis of Flexible Pavement Rutting Behavior (PAVRUT)," D. L. Allen and R. C. Deen, December 1985 (for presentation to the 1986 annual meeting of the Transportation Research Board).

- UKTRP-85-32 "The Feasibility of Draglines for Mine Reclamation," Mark Anderson, December 1985 (Proceedings, 1985 Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, December 9-13, 1985).
- UKTRP-86-1 "Traffic Accident Rates in Kentucky (1984)," K. R. Agent, January 1986.
- UKTRP-86-2 "A Generalized Slope Stability Computer Program: User's Guide for HOPK-1," T. C. Hopkins, January 1986.
- UKTRP-86-3 "Workshop on Roadway and Street Drainage," R. D. Hughes and D. L. Allen, January 1986.
- UKTRP-86-4 "Delineation of Horizontal Curves," K. R. Agent and Tom Creasey, March 1986.
- UKTRP-86-5 "Evaluation of a Full-depth Asphaltic Concrete Pavement," H. F. Southgate, G. W. Sharpe, M. Anderson, and R. C. Deen, April 1986; prepared for presentation to Sixth International Conference on Structural Design of Asphalt Pavements, Ann Arbor, Michigan, July 13-16, 1987.
- UKTRP-86-6 "Effects of Load Distributions and Axle and Tire Configuration on Pavement Fatigue," H. F. Southgate and R. C. Deen, April 1986; prepared for presentation to Sixth International Conference on Structural Design of Asphalt Pavements, Ann Arbor, Michigan, July 13-16, 1987.
- UKTRP-86-7 "Nondestructive Evaluation of Rigid Pavements Using Road Rater Deflections," G. W. Sharpe, M. Anderson, R. C. Deen, and H. F. Southgate, April 1986.
- UKTRP-86-8 "Stability of Embankments on Clay Foundations," T. C. Hopkins, April 1986.
- UKTRP-86-9 "Use of Nondestructive Testing to Prevent Failures of In-Service Metal Bridges," T. Hopwood and R. C. Deen, April 1986; prepared for presentation to 2nd International Conference on Structural Failure, Product Liability and Technical Insurance, Vienna, Austria, July 1-3, 1986.
- UKTRP-86-10 "Use of Post Delineators on Interstates," K. R. Agent and J. G. Pigman, April 1986.
- UKTRP-86-11 "Treatment of Narrow Medians on Four-Lane Rural Roadways," J. G. Pigman and K. R. Agent, April 1986.
- UKTRP-86-12 "Documentation for 1986 Weight-Distance Tax Analyses Using Lotus 1-2-3," H. F. Southgate, April 1986.

- UKTRP-86-13 "Evaluation of Durable Crosswalk and Stopbar Marking Materials," K. R. Agent and J. G. Pigman, May 1986.
- UKTRP-86-14 "Thickness Design Curves for Asphaltic Concrete on a 4-inch Layer of Dense-Graded Aggregate, or on 6, 9, or 12 Inches of Stabilized Soil, or for Maximum Utilization of Dense-Graded Aggregate," H. F. Southgate, May 1986.
- UKTRP-86-15 "Evaluation of Durable Lane Delineation Materials," K. R. Agent and J. G. Pigman, May 1986.
- UKTRP-86-16 "Evaluation of Snowplowable Marker Installations," K. R. Agent and J. G. Pigman, June 1986.

PAPERS, FY 1986

G. W. Sharpe, R. C. Deen, H. F. Southgate and Mark Anderson, "Pavement Thickness Design Using Low-Strength (Pozzolanic) Base and Subbase Materials," Record 1043, Transportation Research Board, 1985

D. W. Prine and T. Hopwood, "Detection of Fatigue Cracks in Highway Bridges with Acoustic Emission," Journal of Acoustic Emission, Vol 4, No. 213, April-September 1985, pp 5304-5306

H. F. Southgate, "Effects of Load Distributions and Axle and Tire Configurations on Pavement Fatigue," Proceedings, 32nd Annual Bituminous Conference, University of Minnesota, November 1985

Mark Anderson, "The Feasibility of Draglines for Mine Reclamation," Proceedings, Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, December 1985

T. Hopwood and D. W. Prine, "Acoustic Emission Structural Monitoring in Noisy Environments Using Event-Based Processing," Proceedings, International Conference and Exposition on Fatigue, Corrosion Cracking, Fracture Mechanics, and Failure Analysis, December 1985

D. L. Allen and R. C. Deen, "A Computerized Analysis of Flexible Pavement Rutting Behavior (PAVRUT)," Transportation Research Board, January 1986

J. G. Pigman and K. R. Agent, "Impact Evaluation of Traffic Alcohol Programs: Selected Locations in Kentucky," Transportation Research Board, January 1986

PRESENTATIONS, FY 1986

R. C. Deen, Short Course on Stability Analysis of Refuse Embankments, Hollow Fills, and Spoil Banks, Institute for Mining and Minerals Research, October 1985, Lexington, KY

T. Hopwood, "Detection of Fatigue Cracks in Highway Bridges with Acoustic Emission," Second International Conference on Acoustic Emission, October 31, 1985, Lake Tahoe, NV

H. F. Southgate, "Effects of Tire Pressure on Pavement Fatigue," 32nd Annual Bituminous Conference, University of Minnesota, November 26, 1985, St. Paul, MN

M. Anderson, "The Feasibility of Draglines for Mine Reclamation," Symposium on Surface Mining, Hydrology, Sedimentology, and Reclamation, University of Kentucky, December 9-13, 1985, Lexington, KY

D. L. Allen and R. C. Deen, "A Computerized Analysis of Flexible Pavement Rutting Behavior," Transportation Research Board, January 1986, Washington, DC

T. Hopwood, "Acoustic Emission Inspection of Steel Bridges," Transportation Research Board, Committee on Structures Maintenance, January 13, 1986.

J. G. Pigman and K. R. Agent, "Impact Evaluation of Traffic Alcohol Programs: Selected Locations in Kentucky," Transportation Research Board, January 1986, Washington, DC

R. C. Deen, Short Course on Engineering Uses of Geosynthetic Fabrics, Institute for Mining and Minerals Research, February 4-6, 1986, Lexington, KY

R. D. Hughes and D. L. Allen, Workshop on Roadway and Street Drainage, Kentucky Transportation Center, February 6, 1986, Erlanger, KY

D. L. Allen, Workshop on Embankment Construction, Kentucky Transportation Center, February 25, 1986, Lexington, KY

R. D. Hughes, Workshop on Underground Conduits, Kentucky Transportation Center, February 25, 1986, Lexington, KY

R. C. Deen, Oroville Dam and Soil Strengthening with Mesh Elements, Kentucky Geotechnical Engineering Group, March 4, 1986, Frankfort, KY

J. G. Pigman and K. R. Agent, Workshop on Traffic Control in Work Zones, Kentucky Transportation Center, April 3, 1986, Lexington, KY

J. G. Pigman and K. R. Agent, Workshop on Traffic Control in Work Zones, Kentucky Transportation Center, April 23, 1986, Hazard, KY

R. C. Deen, Short Course on Fundamentals of Geotechnical Engineering (Soil Mechanics), Institute for Mining and Minerals Research, March 26-27, 1986, Pikeville, KY

R. D. Hughes and D. L. Allen, Workshop on Roadway and Street Drainage, Kentucky Transportation Center, May 15, 1986, Morehead, KY

J. G. Pigman and K. R. Agent, Workshop on Traffic Control in Work Zones, Kentucky Transportation Center, May 1, 1986, Owensboro, KY

J. G. Pigman and K. R. Agent, Workshop on Traffic Control in Work Zones, Kentucky Transportation Center, May 20, 1986, Louisville, KY

J. G. Pigman and K. R. Agent, Workshop on Traffic Control in Work Zones, Kentucky Transportation Center, June 6, 1986, Florence, KY

K. R. Agent, "Treatment of Narrow Medians on Four-Lane Rural Roadways," AASHTO Subcommittee on Design, June 25, 1986, Lexington, KY

TRAINING, FY 1986

L. L. Hamon and J. M. Dunn, Workshop on WORDSTAR, University of Kentucky, July 30-August 15, 1985, Lexington, KY

J. M. Dunn, Workshop on DISPLAYWRITE, University of Kentucky, August 19-23, 1985, Lexington, KY

D. Q. Hunsucker, Workshop on Road Surface Management for Local Governments, Federal Highway Administration, October 24-25, 1985, Lexington, KY

D. L. Allen and R. C. Deen, Seminar on Earthquake Fundamentals for the Mississippi Valley, Earthquake Engineering Research Institute, October 29, 1985, Memphis, TN

D. L. Allen, R. C. Deen, and T. C. Hopkins, Workshop on Design and Construction of Driven Pile Foundations, Federal Highway Administration, November 18-22, 1985, Frankfort, KY

L. L. Hamon, Workshop on LOTUS-1-2-3, University of Kentucky, January 6-9, 1986, Lexington, KY

N. E. Bratton, Workshop on VOLKSWRITER, University of Kentucky, February 3-4, 1986, Lexington, KY

R. C. Deen, Workshop on General Blasting Techniques and Explosive Regulations, Institute for Mining and Minerals Research, February 20-21, 1986, Lexington, KY

R. C. Deen and T. Hopwood, Steel Bridge Seminar, American Institute of Steel Construction, February 27, 1986, Frankfort, KY

R. C. Deen, G. W. Sharpe, and H. F. Southgate, Workshop on Road Surface Management for Local Governments, Federal Highway Administration, March 11-12, 1986, Louisville, KY

D. L. Allen, T. C. Hopkins, and B. W. Meade, Workshop on Permanent Ground Anchors, Federal Highway Administration, March 18, 1986, Frankfort, KY

D. L. Allen, T. C. Hopkins, and B. W. Meade, Workshop on Introduction to Drilled Shafts, March 19-20, 1986, Frankfort, KY

R. C. Deen, Workshop on Ground Water Monitoring Principles and Sampling Techniques, Institute for Mining and Minerals Research, April 14-15, 1986, Lexington, KY

R. C. Deen, Drug Abuse in the Workplace, Human Resources Services, University of Kentucky, May 13, 1986, Lexington, KY

N. E. Bratton, Communicating Bad News to Employees, Human Resources Services, University of Kentucky, June 19, 1986, Lexington, KY

MEETINGS, FY 1986

R. C. Deen, Eleventh International Conference on Soil Mechanics and Foundation Engineering, August 10-17, 1985, San Francisco, CA

D. L. Allen, R. C. Deen, J. H. Havens, G. W. Sharpe, and H. F. Southgate, Strategic Highway Research Program National Workshop, September 18-20, 1985, Dallas/Fort Worth, TX

D. L. Allen, M. Anderson, R. C. Deen, T. C. Hopkins, B. W. Meade, G. W. Sharpe, and H. F. Southgate, Ohio River Valley Soils Seminar on Applied Soil Dynamics, October 11, 1985, Lexington, KY

T. Hopwood, Second International Conference on Acoustic Emission, October 28-November 1, 1985, Lake Tahoe, NV

R. C. Deen and H. F. Southgate, Task Force on Traffic Analyses and EAL Prediction, Federal Highway Administration, November 7, 1985, McLean, VA

T. Hopwood, International Conference and Exposition on Fatigue, Corrosion Cracking, Fracture Mechanics, and Failure Analysis, December 2-6, 1985, Salt Lake City, UT

R. C. Deen, Committee on Publications, American Society for Testing and Materials, December 5-6, 1985, Nashville, TN

K. R. Agent, D. L. Allen, R. C. Deen, T. Hopwood, D. Q. Hunsucker, J. G. Pigman, G. W. Sharpe, and H. F. Southgate, Annual Meeting of Transportation Research Board, January 13-16, 1986, Washington, DC

T. Hopwood and G. W. Sharpe, Meeting of Council of University Transportation Centers, January 16, 1986, Washington, DC

J. H. Havens, Twenty-First Kentucky Concrete Conference, January 23, 1986, Louisville, KY

R. C. Deen, Committee D-18 on Soil and Rock, American Society for Testing and Materials, January 26-28, 1986, Cocoa Beach, FL

R. C. Deen and H. F. Southgate, Task Force on Traffic Analyses and EAL Prediction, Federal Highway Administration, March 18-20, 1986, Orlando, FL

K. R. Agent and J. G. Pigman, Annual Technical Meeting of Kentucky Division, Southern Section, Institute of Transportation Engineers, April 1, 1986, Lexington, KY

R. C. Deen, Committee on Publications, American Society for Testing and Materials, May 22-23, 1986, Philadelphia, PA

H. F. Southgate, Committee E-17 on Pavement Surface Characteristics and Task Group on Weigh-In-Motion, American Society for Testing and Materials, June 2-3, 1986, San Antonio, TX

R. C. Deen, Council of University Transportation Centers, June 5-6, 1986, Orlando, FL

R. C. Deen, Annual Meetings of Committee D-4 on Road and Paving Materials, Committee D-18 on Soil and Rock, and Committee D-35 on Geotextiles and Related Products, American Society for Testing and Materials, June 15-20, 1986, Louisville, KY

H. F. Southgate, Committee D-4 on Road and Paving Materials, American Society for Testing and Materials, June 18, 1986, Louisville, KY

D. L. Allen and T. C. Hopkins, Symposium on Advanced Triaxial Testing of Soil and Rock, American Society for Testing and Materials, June 19-20, 1986, Louisville, KY

R. C. Deen, Southern Research Managers' Conference, Federal Highway Administration, June 23-24, 1986, Oklahoma City, OK

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

- R. C. Deen, Member
- J. H. Havens, Vice President, Kentucky Chapter

American Society of Civil Engineers

- D. L. Allen, Member
- D. L. Allen, Member, Kentucky Geotechnical Engineering Group
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group
- J. H. Havens, Member
- T. C. Hopkins, Member
- T. C. Hopkins, Member, Kentucky Geotechnical Engineering Group
- R. C. Deen, Member, Computer Users Group

American Society for Testing and Materials

- R. C. Deen, Chairman, Committee on Publications
- R. C. Deen, Vice-Chairman, Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Committee on Geotextiles and Related Products (D-35)
- H. F. Southgate, Member, Task Group on Weigh-In-Motion of Committee on Traveled Surface Characteristics (E-17)
- R. C. Deen, Member, Committee on Traveled Surface Characteristics (E-17)
- R. C. Deen, Member, Committee on Road and Paving Materials (D-4)
- R. C. Deen, Member, Pavement Management Subcommittee of Committee on Traveled Surface Characteristics (E-17)
- R. C. Deen, Member, Bearing Tests of Soils in Place Subcommittee of Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Non-destructive Testing of Pavement Structures Subcommittee of Committee on Road and Paving Materials (D-4)

Institute of Transportation Engineers

- K. R. Agent, Member, Warrants for Permissive/Exclusive Left-Turn Phase Committee
- K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee
- K. R. Agent, Member, Warrants for Left-Turn Storage Lanes Committee
- J. G. Pigman, Member, Large Truck Accidents Committee
- J. G. Pigman, Member, Guidelines for Accident Reduction Committee
- G. W. Sharpe, Member

Kentucky Society of Professional Engineers

- D. L. Allen, Member
- R. C. Deen, Member, Chairman of History Committee
- J. H. Havens, Member
- J. G. Pigman, Member

SUMMARY OF ACTIVITIES
FISCAL YEAR 1987

ANNUAL SUMMARY, FY 1987

The Kentucky Transportation Research Program completed the sixth full year as a department within the University of Kentucky College of Engineering in a very positive manner. Total funds for new studies undertaken during fiscal year 1987 exceeded those received for new studies undertaken during fiscal year 1986.

The HPR program under the Kentucky Transportation Cabinet included 21 studies for a FY-87 funding of \$1,204,050. Two new studies under that program were initiated and eight previously initiated studies were concluded. Additional studies initiated during the fiscal year under the auspices of the Kentucky Transportation Cabinet included four Federal-Aid Research Tasks, two Federal Highway Administration Task Orders, three Kentucky Highway Investigative Tasks, and seven State Highway Quick Response Studies. Total funding for those studies amounted to \$312,233. Numerous other non-HPR studies administered by the Kentucky Transportation Cabinet and initiated during previous fiscal years were ongoing and actively pursued.

Eight new studies for other governmental agencies or consulting firms were undertaken at a total funding level of \$304,648. In addition, several informal and impromptu type studies were undertaken and completed for those agencies during the year at a funding level of approximately \$20,000. Kentucky Transportation Research Program investigators also served as instructors for various workshops and made field inspections, upon request, to aid county road crews in correcting unusual problems.

Twenty-seven major reports were finalized and distributed during the year. In addition, a multitude of memorandum or abbreviated reports were prepared and forwarded to appropriate agencies in situations where information was needed rapidly and time was of essence. Twenty-six papers and presentations were offered at various conferences, meetings, and the Transportation Research Board.

Studies undertaken covered a broad range of subject areas within the transportation discipline. Four separate studies were actively pursued for the purpose of devising methods whereby waste products may be effectively utilized in paving structures. A new HPR study that should be of considerable interest to the general public is entitled Evaluation

of Transportation Facilities for Earthquake Hazard Mitigation. Under that study, routes that could be used for evacuation in the event of an earthquake will be studied to determine modifications that might be needed to insure the routes would remain operable during and after a quake.

Several studies in the areas of operations and safety were initiated. Studies involving flexible delineator posts, delineator buttons, various pavement marking materials, breakaway utility poles, and guardrail end treatments were pursued in a continuing effort to enhance safety. Congress mandated the use of unmanned radar units along a section of I 75 in northern Kentucky be studied to determine the effectiveness of those units in reducing speeds and/or accidents. KTRP investigators have worked cooperatively with Kentucky Department of Highways District 6 personnel on that study. Another safety related study evaluated means of controlling traffic at rural, high-speed intersections. A similar type study concerned traffic control in construction and maintenance work zones.

Other studies dealt with such topics as edge drains, pavement design, use of shales, pavement management, use of sandstones, stability of asphaltic mixtures, skid resistance of aggregates, acoustic emission testing, evaluation of specially constructed bridges, traffic volume estimates, and long-term monitoring of experimental features.

The value of studies conducted by Kentucky Transportation Program investigators is evidenced by widespread implementation of findings and recommendations. Revised methods for compaction of shale embankments were developed and implemented. It is anticipated that large sums of money will be saved through reductions in embankment failures. Findings from safety studies are expected to reduce accident potentials and in turn reduce accident-associated costs and deaths and injuries. Preliminary results of the study on waste materials indicate those materials may effectively be used in paving structures. Those studies would provide means for disposing of waste materials in a constructive and cost-effective manner.

The Research Program was conducted by a team of 15 research engineers and 17 technicians and support staff. Fifteen undergraduate students and nine graduate students were employed on a part-time basis. Engineers were active in professional organizations and various training

programs throughout the year to keep abreast of rapidly changing technology and management and administrative techniques. Several engineers have accepted leadership roles in organizations, serving as directors and chairing committees.

REPORTS PUBLISHED, FY 1987

- UKTRP-86-17 "Performance Monitoring of a Highway Tieback Wall," B. W. Meade, D. L. Allen, and T. C. Hopkins, July 1986.
- UKTRP-86-18 "Economic Analyses of Millings," H. F. Southgate, July 1986.
- UKTRP-86-19 "I-75 Lane Closures," J. G. Pigman and K. R. Agent, August 1986.
- UKTRP-86-20 "1986 Safety Belt and Child Safety Seat Usage Rates in Kentucky," K. R. Agent, September 1986.
- UKTRP-86-21 "Distributions of Strain Components and Work within Flexible Pavement Structures," H. F. Southgate and R. C. Deen, September 1986.
- UKTRP-86-22 "Design of Highway Embankments on Unstable Natural Slopes," C. S. Bishop, D. W. Armour, and T. C. Hopkins, September 1986 (also Proceedings, Ohio River Valley Soils Seminar, Louisville, Ky, October 17, 1986.
- UKTRP-86-23 "Manual on Bridge/Culvert Maintenance," G. W. Sharpe and T. Hopwood, September 1986.
- UKTRP-86-24 "Lime Stabilization of Pavement Subgrade Soils of Section AA-19 of the Alexandria-Ashland Highway," T. C. Hopkins and D. L. Allen, October 1986.
- UKTRP-86-25 "Rutting and Longitudinal Cracking and Temperature Cracking: A Case Study (US 23, Greenup County, MP 6.0 to 28.8)," J. H. Havens, G. W. Sharpe, D. L. Allen, and D. Q. Hunsucker, November 1986.
- UKTRP-86-26 "Shrinkage Compensating Deck Concrete (KY 1974 Bridge over Tates Creek Road)," D. Q. Hunsucker, November 1986.
- UKTRP-86-27 "Investigation of Collapse of Long-Span Structure under KY 80 in Floyd County," R. D. Hughes, D. L. Allen, and R. C. Deen, November 1986.
- UKTRP-86-28 "Impact Evaluation of the Lexington-Fayette County Traffic Alcohol Program (1982-1986)," J. G. Pigman and K. R. Agent, November 1986.
- UKTRP-86-29 "Status Report for Selected Projects Containing Experimental Features," December 1986.
- UKTRP-87-1 "Bridge Decks and Overlays," J. H. Havens, Theodore Hopwood, and E. E. Courtney, January 1987.

- UKTRP-87-2 "Automated Data Acquisition for Low-Volume Road Inventory and Management," T. Hopwood, G. W. Sharpe, J. W. Hutchinson, and R. C. Deen, January 1987 (for Fourth International Conference on Low Volume Roads, Cornell University, Ithaca, NY, August 16-20, 1987).
- UKTRP-87-3 "Evaluation of 1985 AASHTO Flexible Pavement Design Equations and Nomographs," H. F. Southgate, G. W. Sharpe, and R. C. Deen, January 1987.
- UKTRP-87-4 "Civil Engineering Applications of Acoustic Emission," Theodore Hopwood II, February 1987 (prepared as a contribution to NONDESTRUCTIVE TESTING, The American Society for Nondestructive Testing).
- UKTRP-87-5 "Summary of Experimental Bridge Features," Theodore Hopwood II, J. H. Havens, and E. E. Courtney, March 1987. 1986.
- UKTRP-87-6 "Traffic Control and Accidents at Rural, High-Speed Intersections," K. R. Agent, March 1987.
- UKTRP-87-7 "Acoustic Emission Monitoring of Bascule Bridge Components," Theodore Hopwood, March 1987.
- UKTRP-87-8 "Design and Performance of Highway Shoulders," D. Q. Hunsucker, G. W. Sharpe, and R. C. Deen, March 1987.
- UKTRP-87-9 "Evaluation of Drainage on Nicholasville Bypass," D. L. Allen, May 1987.
- UKTRP-87-10 "Evaluation and Application of Roadway Delineation Techniques," K. R. Agent and J. G. Pigman, May 1987.
- UKTRP-87-11 "Evaluation of Construction Zone Pavement Marking Materials," K. R. Agent and J. G. Pigman, May 1987.
- UKTRP-87-12 "User's Guide for Pavement Condition Surveys," G. W. Sharpe, H. F. Southgate, and R. C. Deen, June 1987.
- UKTRP-87-13 "Allocation of Resurfacing Monies to Highway Districts in Kentucky," R. L. Rizenbergs and R. C. Deen, June 1987 (for Second North American Conference on Managing Pavements, Toronto, Ontario, Canada, November 2-6, 1987).
- UKTRP-87-14 "Performance Evaluation of Breakaway-Cable-Terminal End Treatments," J. G. Pigman and K. R. Agent, June 1987.

PAPERS, FY 1987

C. S. Bishop, D. W. Armour, and T. C. Hopkins, "Design of Highway Embankments on Unstable Natural Slopes," Proceedings, Ohio River Valley Soils Seminar, 1986.

N. Tollner, "Including Graphics in SCRIPT Documents," The Kentucky Register, University of Kentucky Computing Center, Vol 20, Issue 9, May 1987.

PRESENTATIONS, FY 1987

K. R. Agent, "Safety Features for Local Roads and Streets," Workshop for Kentucky Transportation Center, July 10, 1986, Mayfield, KY.

H. F. Southgate, "Workshop on Road Rater Analyses," Los Angeles County Highway Department, August 4-8, 1986, Los Angeles, CA.

H. F. Southgate, "Workshop on Road Rater Analyses," August 22, 1986, Cook County, Vancouver, WA.

D. L. Allen, "Factors Influencing Rutting in Flexible Pavements," Annual Meeting of Southeastern Association of State Highway and Transportation Officials, September 15, 1986, Louisville, KY.

D. L. Allen, "Loads on Box Culverts," Annual Meeting of Southeastern Association of State Highway and Transportation Officials, September 15, 1986, Louisville, KY.

J. G. Pigman and K. R. Agent, "Evaluation and Application of Roadway Delineation Techniques," Annual Meeting of Southeastern Association of State Highway and Transportation Officials, September 16, 1986, Louisville, KY.

K. R. Agent, "Guidelines for Use of Protected/Permissive Left-Turn Phasing," Annual Meeting of Southeastern Association of State Highway and Transportation Officials, September 16, 1986, Louisville, KY.

H. F. Southgate, "Truck Design and Usage Related to Highway Pavement Performance," Second International Conference on the Bearing Capacity of Roads and Airfields, September 15-18, 1986, Plymouth, England.

R. C. Deen, "Drilling and Sampling of Subsurface Materials," Short Course for Institute for Mining and Minerals Research, September 16-18, 1986, Lexington, KY.

H. F. Southgate, "Workshop on Pavement Management," Workshop for Kentucky Transportation Center, October 16-17, 1986, Hopkinsville, KY.

C. S. Bishop, D. W. Armour, and T. C. Hopkins, "Design of Highway Embankments on Unstable Natural Slopes," Ohio River Valley Soils Seminar, October 17, 1986, Louisville, KY.

T. Hopwood and G. W. Sharpe, "Bridge Maintenance Workshop," Workshop for Kentucky Transportation Center, October 21, 1986, Lexington, KY.

R. C. Deen, "Stability Analysis of Refuse Embankments, Hollow Fills, and Spoil Banks," Short Course for Institute for Mining and Minerals Research, October 22-23, 1986, Lexington, KY.

T. C. Hopkins, "Lime Stabilization of Pavement Subgrade Soils of Section AA-19 of the Alexandria-Ashland Highway," Soil-Lime Stabilization Seminar, Dravo Corp., November 12, 1986, Lexington, KY.

J. G. Pigman and K. R. Agent, "Safety Features for Local Roads and Streets," Workshop for Kentucky Transportation Center, November 12-13, 1986, Richmond, KY.

T. C. Hopkins, "HOPK-I Slope Stability Computer Program," Workshop for Kentucky Department of Highways, November 26, 1986, Frankfort, KY.

T. Hopwood and G. W. Sharpe, "Bridge Maintenance Workshop," Workshop for Kentucky Transportation Center, December 4, 1986, Prestonsburg, KY.

T. Hopwood, "Weld Inspection," Transportation Research Board Committee on Fabrication and Inspection of Metal Structures, January 13, 1987, Washington, D.C.

H. F. Southgate, Presider of Technical Sessions 135 and 213, Annual Meeting of Transportation Research Board, January 14, 1987, Washington, D.C.

T. C. Hopkins, "HOPK-I Slope Stability Computer Program," Workshop for Kentucky Department of Highways, January 28, 1987, Frankfort, KY.

K. R. Agent and J. G. Pigman, "Traffic Control in Work Zones," Workshop for Kentucky Transportation Center, March 3, 1987, Florence, KY; March 10, 1987, Covington, KY; March 12, 1987, Frankfort, KY; March 13, 1987, Frankfort, KY; March 26, 1987, Owensboro, KY.

T. C. Hopkins, "Use of Lime for Stabilizing Pavement Subgrades in Kentucky," Highway Seminar, National Lime Association, March 12, 1987, Lexington, KY.

G. W. Sharpe, "Pavement Engineering for Local Governments," Kentucky Association of Planners, April 9, 1987, Barren River State Park, Lucas, KY.

T. Hopwood, "Evaluation of the Acoustic Emission Weld Monitor," Federal Highway Administration, May 20, 1987, McLean, VA.

TRAINING, FY 1987

L. L. Hamon, "Beginning D-base III," University of Kentucky, October 16, 1986, Lexington, KY.

L. L. Hamon, "Advanced D-base III," University of Kentucky, October 17, 1986, Lexington, KY.

D. L. Allen, R. C. Deen, and T. C. Hopkins, "Tensar Geogrid Design Seminar," Tensar Corporation, August 12, 1986, Lexington, KY.

T. Hopwood, "Bridge Rehabilitation Workshop," Byrd, Tallamy, McDonald and Lewis and Kentucky Transportation Center, August 13-15, 1986, Lexington, KY.

T. Hopwood, "Strain-gage Workshop," Measurements Group, Inc., September 22-26, 1986, Raleigh, NC.

G. W. Sharpe, "Pavement Management: The PAVER System," University of Illinois, October 14-17, 1986, Urbana, IL.

D. L. Allen, R. C. Deen, and T. C. Hopkins, "Foundations in and on Rock," Seminar presented by Professor Fred H. Kulhawy of Cornell University, Sponsored by Kentucky Geotechnical Engineering Group, November 13, 1986, Lexington, KY.

T. Hopwood, "Bridge Management Workshop," Transportation Research Board, January 11, 1987, Washington, D.C.

R. C. Deen, "Your Instructional Styles, Your Students' Learning," University of Kentucky Counseling and Testing Center, February 10 and 12, 1987, Lexington, KY.

T. Hopwood and D. Q. Hunsucker, "Bridge Inspection Workshop," University of New Mexico and Kentucky Transportation Cabinet, March 2-13, 1987, Louisville, KY.

R. C. Deen, "Managing Multiple Priorities," Dun & Bradstreet Business Education Services, March 26, 1987, Lexington, KY.

H. F. Southgate and R. C. Deen, "Micro/Mainframe PAVER Training," American Public Works Association, April 21-23, 1987, Atlanta, GA.

J. G. Pigman, Tort Liability/Risk Management Workshop, Kentucky Transportation Center, April 27, 1987, Lexington, KY.

K. R. Agent, Tort Liability/Risk Management Workshop, Kentucky Transportation Center, April 28, 1987, Frankfort, KY.

K. R. Agent, Highway Hazards: Correction, Protection, and Liability, Transafety, May 7-8, 1987, Cincinnati, OH.

T. Hopwood and V. K. Oka, "Inspection of Fracture-Critical Bridge Members," Byrd, Tallamy, McDonald and Lewis and Kentucky Transportation Cabinet, June 23-24, 1987, Frankfort, KY.

MEETINGS, FY 1987

K. R. Agent and J. G. Pigman, Traffic Records Forum, National Safety Council, July 14-18, 1986, Lexington, KY.

R. C. Deen and H. F. Southgate, Traffic Forecasting for Pavement Design, Multi-state Task Group, Federal Highway Administration, August 18-20, 1986, Newport, OR.

K. R. Agent, D. L. Allen, and G. W. Sharpe, Annual Meeting, Southeastern Association of State Highway and Transportation Officials, September 15-19, 1986, Louisville, KY.

M. Isenhour and G. W. Sharpe, Annual Meeting of Kentucky Municipal League, September 18-19, 1986, Fort Thomas, KY.

D. L. Allen, B. W. Meade, and T. C. Hopkins, 18th Annual Southeastern Transportation Association of Geotechnical Engineers Conference, October 6-10, 1986, Louisville, KY.

M. Anderson, D. L. Allen, R. C. Deen, T. C. Hopkins, D. Q. Hunsucker, and B. W. Meade, Ohio River Valley Soils Seminar, October 17, 1986, Clarksville, IN.

R. C. Deen, J. H. Havens, T. C. Hopkins, D. Q. Hunsucker, and H. F. Southgate, Lime Stabilization Seminar, Dravo Corporation, November 12, 1986, Lexington, KY.

M. Isenhour and G. W. Sharpe, Annual Meeting of Kentucky Association of Counties, November 18-21, 1986, Owensboro, KY.

R. C. Deen, Committee D.04 on Road and Paving Materials and Committee E.17 on Traveled Surface Characteristics, American Society for Testing and Materials, December 1-3, 1986, New Orleans, LA.

R. C. Deen, Committee on Publications, American Society for Testing and Materials, December 15-16, 1986, St. Petersburg, FL.

J. G. Pigman, Workshop on Human Factors in Transportation, Transportation Research Board, January 11, 1987, Washington, DC.

T. Hopwood, Workshop on Bridge Maintenance Management, Transportation Research Board, January 11, 1987, Washington, DC.

R. C. Deen, T. Hopwood, J. G. Pigman, G. W. Sharpe, and H. F. Southgate, Annual Meeting of Transportation Research Board, January 12-15, 1987, Washington, DC.

H. F. Southgate, Truck Tire Symposium/Workshop, American Association of State Highway and Transportation Officials, February 12-13, 1987, Austin, TX.

D. L. Allen, R. C. Deen, T. C. Hopkins, G. W. Sharpe, and H. F. Southgate, Highway Seminar, National Lime Association, March 12, 1987,

Lexington, KY.

G. W. Sharpe, Kentucky Association of Planners, April 9, 1987, Barren River State Park, Lucas, KY.

D. Q. Hunsucker, Katharine and Bryant Mather International Conference on Concrete Durability, April 27 - May 1, 1987, Atlanta, GA.

AWARDS, FY 1987

J. H. Havens, Life Membership, American Society of Civil Engineers, November 1986.

R. C. Deen, Honorary Member, Committee on Soil and Rock, American Society for Testing and Materials, June 22, 1987.

PROFESSIONAL ACTIVITIES AND ASSOCIATIONS

American Public Works Association

- R. C. Deen, Member
- J. H. Havens, Vice President, Kentucky Chapter

American Society of Civil Engineers

- D. L. Allen, Member
- D. L. Allen, Chairman, Kentucky Geotechnical Engineering Group
- R. C. Deen, Executive Director, Professional Development Fund, Kentucky Geotechnical Engineering Group
- J. H. Havens, Member
- T. C. Hopkins, Member
- T. C. Hopkins, Member, Kentucky Geotechnical Engineering Group
- R. C. Deen, Member, Computer Users Group

American Society for Testing and Materials

- R. C. Deen, Chairman, Committee on Publications
- R. C. Deen, Vice-Chairman, Committee on Soil and Rock (D-18)
- R. C. Deen, Member, Executive Subcommittee of Committee on Soil and Rock (D-18.90)
- R. C. Deen, Member, Identification and Classification of Soils Subcommittee of Committee on Soil and Rock (D-18.07)
- R. C. Deen, Member, Information Retrieval and Data Automation Subcommittee of Committee on Soil and Rock (D-18.95)
- R. C. Deen, Member, Committee on Geotextiles and Related Products (D-35)
- H. F. Southgate, Member, Task Group on Weigh-In-Motion of Committee on Traveled Surface Characteristics (E-17.41)
- R. C. Deen, Member, Committee on Traveled Surface Characteristics (E-17)
- R. C. Deen, Member, Committee on Road and Paving Materials (D-4)
- R. C. Deen, Member, Pavement Management Subcommittee of Committee on Traveled Surface Characteristics (E-17.41)
- R. C. Deen, Member, Bearing Tests of Soils in Place Subcommittee of Committee on Soil and Rock (D-18.10)
- R. C. Deen, Member, Non-destructive Testing of Pavement Structures Subcommittee of Committee on Road and Paving Materials (D-4.39)

Institute of Transportation Engineers

- K. R. Agent, Member, Warrants for Permissive/Exclusive Left-Turn Phase Committee
- K. R. Agent, Member, Use and Timing of Signal Change Intervals Committee
- K. R. Agent, Member, Warrants for Left-Turn Storage Lanes Committee
- J. G. Pigman, Member, Large Truck Accidents Committee
- J. G. Pigman, Member, Guidelines for Improving Traffic Safety Committee
- G. W. Sharpe, Member

Kentucky Society of Professional Engineers

- D. L. Allen, Member
- R. C. Deen, Member, Chairman of Professional Engineers in Education

J. H. Havens, Member
J. G. Pigman, Member
T. C. Hopkins, Member
H. F. Southgate, Member
G. W. Sharpe, Member
D. Q. Hunsucker, Member

Transportation Research Board

K. R. Agent, Member, Instrumentation Principles and Applications Committee
R. C. Deen, Member, Group 2 Council, Design and Construction of Transportation Facilities
R. C. Deen, Member, Chemical Stabilization Committee
R. C. Deen, Member, Engineering Geology Committee
J. G. Pigman, Member, Methodology for Evaluating Highway Improvements Committee
J. G. Pigman, Chairman, Subcommittee on State Program Management
J. G. Pigman, Member, Planning and Administration of Transportation Safety Committee
J. G. Pigman, Member, Traffic Law Enforcement Committee
G. W. Sharpe, Member, Strength and Deformation Characteristics of Pavement Sections
H. F. Southgate, Member, Flexible Pavement Design Committee
H. F. Southgate, Member, Pavement Evaluation Committee
G. W. Sharpe, Member, Rigid Pavement Committee
T. Hopwood, Member, Fabrication and Inspection of Metal Structures
H. F. Southgate, Member, Task Force on Weigh-in-Motion

Others

H. F. Southgate, Member, The Association of Asphalt Paving Technologists
J. H. Havens, Member, The Association of Asphalt Paving Technologists
T. Hopwood, Member, American Welding Society
T. Hopwood, Member, American Society for Metals
T. Hopwood, Member, American Society for Nondestructive Testing
G. W. Sharpe, Member, Controlled Low-Strength Materials Committee, American Concrete Institute

International Society of Soil Mechanics and Foundation Engineers

T. C. Hopkins, Member
R. C. Deen, Member

Kentucky Association of Transportation Engineers

J. H. Havens, Member
R. C. Deen, Member

Professional Women's Forum

Nancy Bratton, Member