

Current Highway Research at Purdue The Joint Highway Research Project

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The highway research program of the Joint Highway Research Project at Purdue University at any one time consists of 40 to 50 projects. These projects vary in size and complexity but typically a project will be performed by a principal investigator under the direction of an experienced research engineer and will be from one to three years in length.

The selection of projects is one of the primary responsibilities of the Advisory Board of the Project and almost every idea for a research project originates with a Board member or some member of the Indiana State Highway Commission. This is as it should be for one of the primary purposes of the Joint Highway Research Project is to provide solutions to problems of the Indiana State Highway Commission.

During this fiscal year 1964-65, 51 research projects have been active and as of the present date, March 1965, 43 highway research projects are active. It has been the practice each year at the research session of the Road School to report in some detail on two to four of the projects. This year only one of the current researches will be reported in detail and I will briefly discuss the other 50 projects which have been or still are active this year.

The current research can be classified into ten areas and the research in each area will be discussed as a group. The first of the areas, in alphabetical order, is Airphoto Interpretation and Photogrammetry.

Airphoto Interpretation and Photogrammetry.

Perhaps the best known and most important activity of this area is the completed and widely known project which produced a drainage map for each county in the state. These maps are available in individual or Atlas form. Currently a state drainage map is in preparation with the

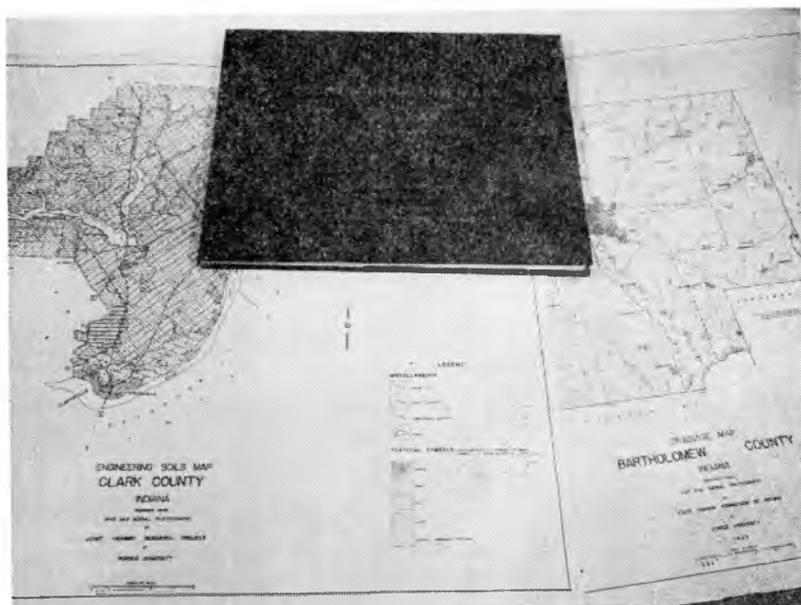


Fig. 1. The Atlas of County Drainage Maps which includes a complete drainage map for each county in Indiana is a product of the Joint Highway Research Program. Copies are available at \$15 each from the Project. Copies of individual county drainage and soil maps are also available at \$2 each.

material on each of the county maps being transferred to a state map. The map is complete except for final review and publication. When published in a few months, a complete drainage map of the state will be available for use in regional and state wide planning operations.

Of equal importance to the drainage mapping is the engineering soils mapping of the state. These maps are also being prepared in county units and maps for 35 of the Indiana counties are now available. The more recent of these maps also include data from sample soil tests as a part of the map. Because two of the most important uses of these maps are in determining the location of a highway improvement and in preparing a soil boring program, most of the effort of the past year in this area has been devoted to the preparation of soil strip maps of the corridors of the proposed routes of the yet-to-be built interstate highways.

Another related project is investigating the reliability of direct and indirect methods of soil exploration to suggest the optimal program of subsurface investigation for a highway improvement. The necessary spacing and depth of soil borings and the use of information from soil

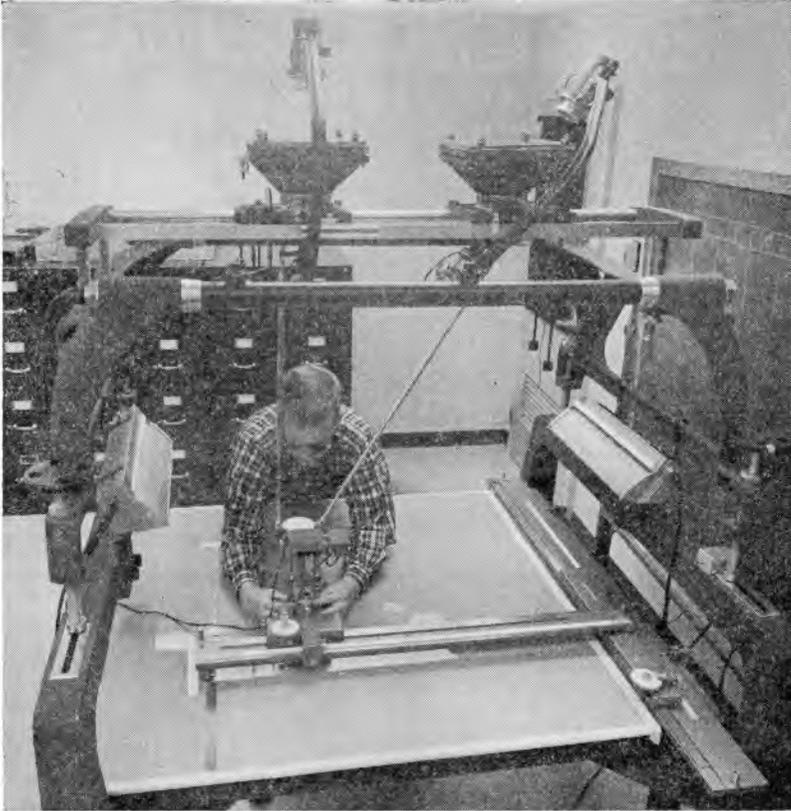


Fig. 2. Research on the accuracy of using photogrammetric methods in right-of-way determination was completed during the year using the Kelsh Plotter, shown above, and field surveys.

tests by design engineers is being evaluated so that a soil test program can be developed which is adequate and economical.

Another research study just getting underway will determine the extent to which multisensor photography and imagery in the ultra violet, infrared and radar spectrum can be used to determine the engineering characteristics of soils. The goal, of course, is to minimize the amount of field exploration required for design purposes.

Research in airphotos also includes a study of the characteristics of watersheds which affect the runoff characteristics. The purpose of the research is to determine how aerial photos can be used to evaluate these affecting characteristics so as to determine the run-off constants in a watershed area for highway structure design.

Finally research in the airphoto area was just completed on the accuracy of using photogrammetric methods in right-of-way determination. The results of photogrammetric surveys were compared with conventional surveying methods for right-of-way purchases and were found to be adequate as well as faster and more economical.

Bituminous Materials and Flexible Pavements

In a second area, bituminous materials and flexible pavements, major effort has been expended for many years in seeking a fundamental understanding of bituminous mixture stability and durability and their measurement by laboratory tests. One current project is directed at evaluating the stress-strain relationships in bituminous concrete under load. This information is of particular importance with the expanding use of bituminous mixtures in the lower layers of pavements where it distributes the load. A second project in this area is investigating the structural behavior of a multi-layer flexible pavement under repeated traffic loads. Hopefully this research will permit a more accurate

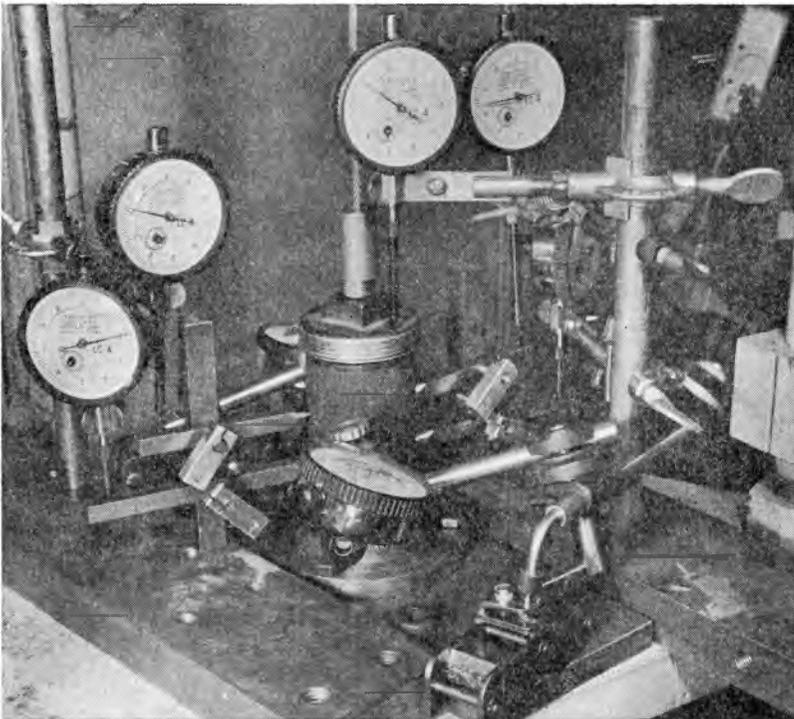


Fig. 3. A uniaxial tension test, in progress in the photograph above, was taken during research on the two dimensional stress-strain relationships of a fine aggregate-asphalt system.

quantitative description of mixture parameters than present design methods provide.

Of continuing interest and study in the bituminous area is the skid characteristics of pavement surfaces. Periodic measurements are made of these characteristics on existing pavements and on special test sections. Included is a study of the polishing characteristics of aggregates and the development of a fine bituminous mixture with high skid resistance characteristics.

Chemistry of Materials

In the area of chemistry of materials, one current research project is concerned with volume change in concrete, a problem suggested as an item of research at a meeting of the Board in Indianapolis at Commission offices. The purpose of this research is to investigate the influence of composition and temperature on the rate of volume change of concrete incorporating expansive cements. A better understanding of the nature of the expansive phase will permit a better utilization of the proper cement in maintenance and construction applications.

A second project in this area is directed at obtaining a better understanding and control of calcium silicate systems and portland cement. Observation and measurement of the properties of orthosilicates and their hydrates that are dependent upon the atomic, molecular and crystal structure of the orthosilicates is the goal of this fundamental study.

Another project, recently completed, in this area was a laboratory investigation of the effect of applying insulation to the underside of concrete slabs, such as on a bridge. Some claims had been made that such application would minimize the freezing of water on bridge decks, thereby minimizing the hazard of a bridge deck freezing before its approaches. The research indicated that such insulation had no effect on the temperature of the surface of the slab and that such insulation would be of little value in eliminating this problem of the early freezing of bridge decks.

Concrete Materials and Rigid Pavements

One of the continuing projects in the concrete laboratory is the durability of coarse aggregates in portland cement concrete to freeze-thaw conditions. Basically this has consisted of an evaluation of those constituents in gravel and stone that are detrimental to concrete under conditions of freezing and thawing. Although much of this work was completed many years ago here at the Project, periodic durability tests are made as requested by the Highway Commission on aggregate from new sources of gravel and stone.

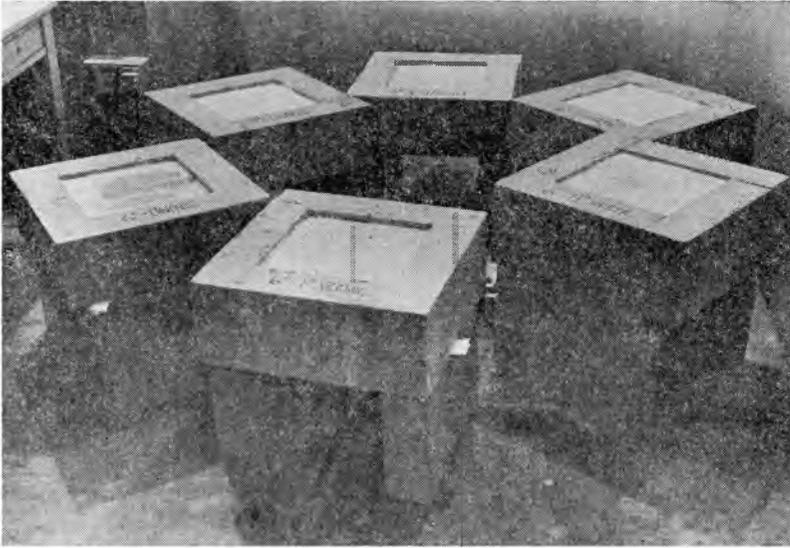


Fig. 4. The testing arrangement of insulated and uninsulated test slabs is shown inside the walk-in cold room for the study of insulation of concrete bridge decks.

Throughout the history of the Project several performance surveys have been made of highway pavements and bridge surfaces at the request of the Highway Commission to determine the causes of deterioration. Such a survey completed in June 1964 of concrete bridge surfaces disclosed some scaling and other deterioration on bridge decks, even though recently constructed. Further investigation disclosed the variables of season of construction and low air content to be possible causes of the failures.

Although adequate air content has been known for some time to be important in the prevention of concrete deterioration, a fool-proof way of insuring adequate air entrainment has not been found. In this problem area, two studies are currently in progress. One of these is a field comparison between portions of a structure which utilized normal air-entrained concrete and other portions which used concrete containing a new additive which is claimed to provide resistance to scaling and deterioration and which is practical and foolproof to use. The results of this project, however, are not yet available.

A second project in this area was just initiated. The purpose of it is to investigate and determine the relationship between fine aggregate gradation characteristics and the amount of air entrained in a portland cement structure. There is some indication that gradation character-



Fig. 5. A bridge deck scaling survey in 1964 found some scaling and other deterioration on bridge surfaces of recent construction. The season of construction and low air content were indicated as possible causes of failure.

istics do influence air content and that proper gradation might be a technique which can be used to improve the air content of portland cement concrete and its durability.

Other research in the concrete area is concerned with the examination of existing theories of pavement performance, the development of new theories, and the testing of these theories utilizing the AASHTO Road Test data. The goal of this study is to develop a road performance hypothesis which will permit extension of the AASHTO Road Test results to other areas of the country.

Another project is a theoretical analysis of concrete slabs partially supported by the ground and subjected to moving loads and temperature variations. The results will be assessed in the light of existing theories of slab performance and pavement design.

Finally this area is also conducting extensive research in the quality control area. The first phase of the research was concerned with tests on plastic concrete produced for highway pavements. The second phase



Fig. 6. A research project in the area of quality control of highway construction included field tests on concrete being placed for a new highway.

will be on the compaction of highway subgrades and bases. In this area, the Project is cooperating with nation-wide Bureau research to obtain data on the quality of elements of the product of the highway construction process. The result of all this research will be to encourage the use of a technique, statistical quality control, which will reasonably insure that a quality highway is being constructed at an economical cost.

Highway Economics

In the area of highway economics, research is active in the area of the impact of highway improvements on traffic, land use, land value and community well-being. The impacts of six highway improvements—a rural interstate highway, a major rural highway without control of access, a controlled access bypass, an uncontrolled access bypass, a major urban improvement, and the interchange area of two interstate highways near a large urban area—are being studied for short term and long term effects. The economics of controlling access, of constructing to four-lane design, and of early purchase of right-of-way is included. Other aspects of this broad study are the effect of highway improvements on accidents, the effect of traffic flow, the effect on amount and type of land use development and the effect on land values. Much important information has already been published from these studies and as the long-term effects are evaluated, it is hoped that more knowledge on the total impact and benefits of major highway improvements will be learned.

A second study in this area has been devoted to what happens to those pieces of property which remain when a part of the original plat is taken for a highway right-of-way. Of special importance here was



Fig. 7. Highway impact research includes a long-term study of the effect of the Kokomo By-pass, pictured above, on traffic, land use, land value and community well being.

an evaluation of the damages to the remaining property under conditions of land locking or separation. One of the items investigated was a comparison of the damages paid with the price obtained by owners for such remainders when sold. Significant findings included the fact that more damages were being paid than actually sustained in a very high percentage of the cases but that a significant number of land owners were not receiving adequate payment for the damages received. Other findings

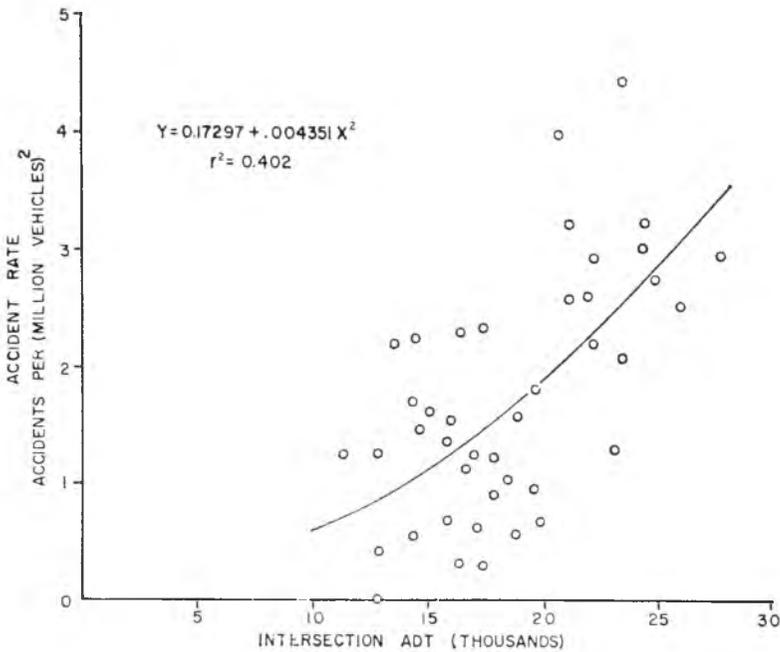


Fig. 8. One of the results of accident research on the Lafayette By-pass was the above graph and mathematical model showing the relationship between accident rate and total intersection traffic volume.

included many case studies of R/W takings, many of which indicated tremendous increases in land value after the highway improvement.

Highway Safety

With the steady increase in traffic accidents and fatalities during the past several years, the Project has placed more emphasis on safety research. Current research in this area includes a comprehensive study of the causes of rail-highway accidents. The research is attempting to evaluate those factors which result in increased hazard at rail-highway crossings and is seeking an evaluation of the protective value of the several types of railroad crossing warning and protective devices. In addition, it is hoped that a method can be developed which will provide a realistic hazard rating for each crossing in the state so that adequate protective measures can be wisely implemented.

Another research project is concerned with accidents at the intersections of major highways. It is commonly believed by many people that traffic signals are the answer to intersection accidents. Experience, however, at many intersections where traffic signals are installed indicates

that accidents will increase. This project is attempting to evaluate the correlation between accident rates and types and the traffic control at intersections. The results may provide better warrants and real evidence to combat the many requests for unwarranted traffic signals while at the same time justifying those that really would reduce accidents significantly.

A third project in this area is seeking to find the urban design and system of traffic control which will provide optimum safety and movement on high-volume urban arterials. Hope of success in this research lies in the fact that some high volume urban arterials have far lower accident rates than other arterials carrying similar volumes. An evaluation of the reasons why this is true may produce knowledge of great benefit in reducing traffic accidents.

Finally, this area is conducting a demonstration project on the U. S. 52 bypass at Lafayette to show the value of applying traffic engineering to this high accident, high volume arterial. This study includes an evaluation of the causes of delay, the causes of accidents, recommendation for improvements and evaluation of the improvements. Included also is the development of a simulation model which will duplicate the results obtained from the traffic engineering changes on this bypass and which can then evaluate other possible changes before they are made at this site and on other similar bypasses, of which we have several in Indiana.

Soils and Pavement Design

In the area of soils and pavement design, a major project is directed at developing instrumentation suitable for measuring actual wheel loads of highway vehicles and the stresses and deflections induced by these loads in the pavement and subgrade. Such measurements will permit realistic evaluation of load-deformation characteristics of pavements and the effect of various construction types, of operating speeds and surface condition. Such evaluation would permit more economical designs and the imposition of wiser controls and maintenance.

A second study is investigating the strength parameters of stabilized soil-aggregate mixtures to determine the type of strength test that should be used to evaluate Indiana aggregates when stabilized with some admixture. A second phase of this research deals with the development of a design method for such pavements so that adequate but economical stabilized pavements can be reliably designed.

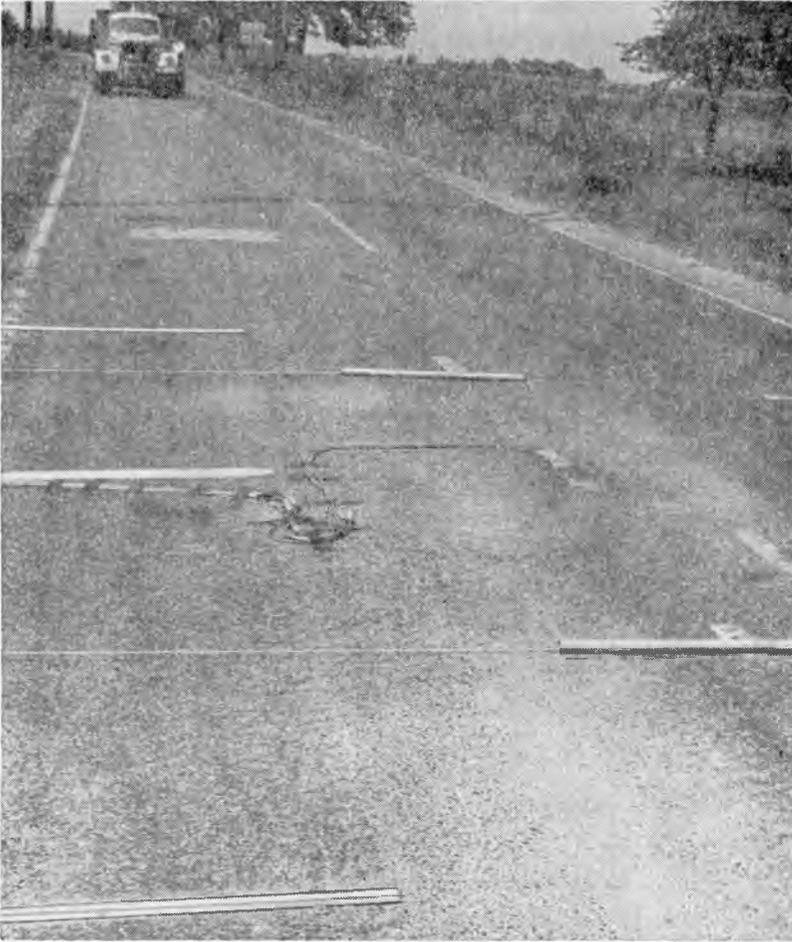


Fig. 9. The typical pavement test installation shown above was one site for the field tests on the research on pavement stresses due to moving loads.

Transportation Planning

In the transportation planning area, because of the great importance of urban transportation planning and the requirement that every major urban area be doing cooperative, continuing, comprehensive transportation planning, emphasis has been placed on developing techniques for obtaining travel patterns in an urban area.

One project investigated the characteristics of travel patterns in several cities and developed analytical models for estimating elements of the travel pattern from characteristics of the urban area and its population. A second project is attempting to use these models to synthesize

the travel patterns in an Indiana city while still another is evaluating the several up-dating techniques that are available for travel pattern studies. The purpose of these studies is to develop a technique for obtaining the travel patterns for an urban area by a means which is adequate, but which is more economical and rapid than the presently used costly and slow origin-destination survey.

Another project in the planning area is aimed at formulating a value function which will permit the assignment of trips to alternate routes in a more realistic and accurate manner than those techniques currently used. The reason for the research is that present techniques are beset with many problems and often produce unrealistic results. The technique sought would also assign traffic to an entire network, the system of arterial streets, rather than to a single or limited number of routes.

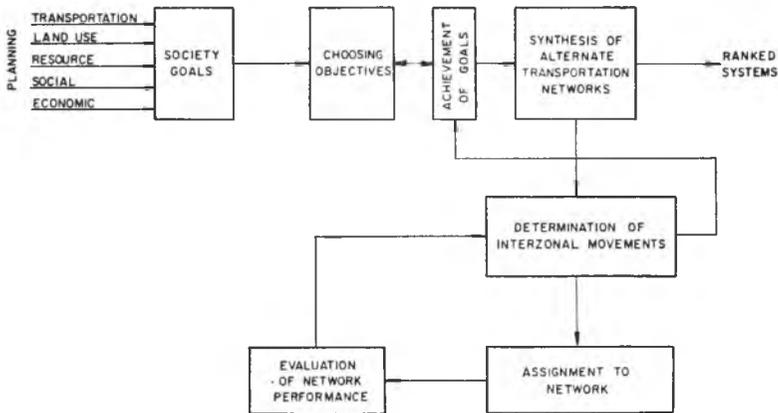


Fig. 10. Considerable research is in progress on the determination of urban interzonal movements (travel patterns) and assignment to networks, two key blocks in the transportation planning system block diagramed above.

Other research in this area is concerned with regional travel patterns. The purpose of the study is to determine the significant factors that result in highway travel between a city and its surrounding region. Perhaps the results will be of great value in regional transportation planning, certainly a responsibility of the Highway Commission.

Another project is attempting to develop a method by which the highway needs of an urban area can be adequately evaluated. In a comprehensive needs study one wishes to evaluate needs of state highways, county roads and city streets. The latter because of the many

complex factors, large volumes of traffic and often poor records is difficult to evaluate. It must be done, however, and a sound but economical and rapid method is being sought.

Still another study in this area is concerned with developing a sampling program for truck weights which will provide accurate highway loadings for each section of the state highway system. Such information on loadings is necessary for the proper design of pavements on new or reconstructed facilities. This research also evaluated the information currently available and found it inadequate to provide the needed loadings for most sections of the State System.

Finally research in this area is also directed at learning something about the trips generated by a new reservoir or recreational area. Of special interest is an evaluation of those factors which cause people to be attracted to such areas so that better planning for transportation and recreational facilities can be performed for each such site, of which many are planned for the coming years.

Traffic Engineering

Research in traffic engineering includes an evaluation of the benefits resulting from the installation of a density controlled signal system in the downtown area of Lafayette. The after conditions will be compared with before conditions in an attempt to develop criteria for installation of such systems in other cities.

Another study is formulating a program for routine maintenance of traffic signals in a highway district. The program is to minimize cost, hazard and maintenance due to burnouts and other routine causes.

One study was a determination of the time gap required by motorists at stop signs to cross a major street. Such information is needed for traffic simulation programs and is useful in developing better traffic signal warrants. Another study investigated the capacity of on-ramps for freeways of different volumes of traffic in the right freeway lane. Two other studies, one on speed trends and the other on the correlation between speed and weight of trucks are trend studies and have been in progress for many years. Both of these studies provide information necessary for road design and planning of future highways as they provide a base for a realistic estimate of future speeds and future loads on highways.

A study was just initiated to develop warrants for the construction of refuge left turn lanes at signalized and non-signalized intersections in rural and suburban areas. The warrants will result from an evaluation of the costs of construction versus the value of accident reductions and reduced delays at intersections due to such left turn lanes.

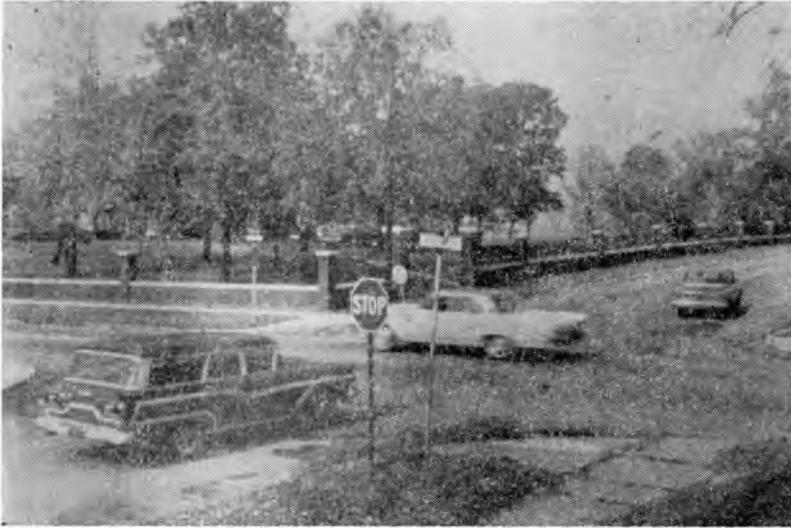


Fig. 11. Determination of the gap between vehicles which are required before motorists on a side street at a stop-controlled intersection will cross was the subject of one traffic engineering research.

Finally a study is in progress to evaluate the cost to the state of painting center lines and edge lines with state personnel. Such information not only will provide the state with information useful in deciding on contract painting but will also permit them to reduce costs by changes in methods which prove to be expensive.

Special Projects

In addition to those projects already enumerated several special projects are in process. In the structural area a study was recently completed on the creep and shrinkage characteristics and their effects on the camber in prestressed beams cast, cured and stored in the field. In the hydraulics area a study of the runoff from small drainage areas resulted in a manual on peak discharge from small watersheds in Indiana. Design hydrographs are included. The manual, extremely useful to designers of drainage structures, is available from the Project.

A study on the development of tests for predicting the amount and effect of aggregate degradation during handling and construction is in progress in the geology department under the National Cooperative Highway Research Program.

Lastly, research has been in progress in the use of herbicides to obtain maximum weed control on roadsides. This study also includes use of soil sterilants around guard posts, bridge ends, etc. It is currently



Fig. 12. The product of one hydraulics study was the manual pictured above. The publication is available from the Joint Highway Research Project at \$1 a copy.

being expanded to include research in other roadside development areas—the development of a better roadside turf, requiring less maintenance and providing better control of erosion, and the development of recommendations for the selection, establishment and maintenance of suitable

roadside plantings. Both of these are directed at improving the beauty of the roadside while at the same time minimizing the maintenance.

Summary

This brief resume of the current highway research at Purdue includes almost every area of highway development. The projects are directed at real problems which are confronted by highway personnel every day and which can provide useful information toward the solution of these problems. There is much other research which could be done for there are many problems yet unsolved. The Advisory Board and the staff, however, have attempted to be selective and to authorize research which is directed at important problems, for the actual value of research to the Highway Commission depends, to a great extent, on the importance of the problem to which the effort is assigned—that is, if the effort is on trivial problems, the rewards are apt to be trivial. Certainly there is nothing trivial about the problems of highway accidents, rising maintenance costs, deteriorating highways, traffic congestion and urban transportation planning. These are the type of problems to which the current research is directed.

Somehow, however, there is always a lingering suspicion among many that research is not really an essential activity—that it could be reduced or even eliminated. Some, perhaps, are wondering about the cost of the research described.

The current expenditure of State Highway funds for Project research is approximately \$250,000 per year—\$160,000 from state funds plus \$90,000 of Federal Aid funds administered by the state. Additional funds from industry, the federal government, the Highway Research Board, the American Association of State Highway Officials, national foundations, the Purdue Research Foundation, the Highway Extension and Research Project for Indiana Counties, and many other organizations and individuals are also received annually for use in highway research and education at Purdue. These funds—which annually approximate the total of state highway funds—are also used for highway research; the results of which are made available to the Indiana Highway Commission and which supplement the research financed by the Highway Commission. The value of the building space and other items of overhead contributed by the University to the operation of the Project must also be included as part of the total financial picture of the Project. The total annual cost of the Joint Highway Research Project is currently about \$500,000, including only \$250,000 of state highway administered funds. As the total product of this effort is made available to the Indiana Highway Commission this is a real bargain for the state.

But the highway research programs of each of the several states, including Indiana, must be increased, for in the words of D. Grant Mickle, formerly Deputy Federal Highway Administrator and now Executive Director of the Highway Research Board, "Highway officials are confronted with increasingly complex problems of both technology and administration. It is evident that improved and new technologies, and methods of assimilating them into the Highway transportation system, must be researched and developed."

And Robert F. Baker, Director of Research and Development of the Bureau of Public Roads has said "I believe strongly that highway transportation problems cannot be solved without the active support and participation of universities. It is not enough that a university is interested in research work or even is competent to solve an individual problem. It must have the ability to undertake projects that may last for a considerable period of time and may be very costly. . . . I know for a fact that good research can be achieved and graduate education can be assisted at the same time."

To meet this need for expanded research, the Indiana State Highway Commission has authorized the construction and development of a Highway Commission Research and Training Center at McClure Research Park in West Lafayette, Indiana. With unity of purpose and the assurance of continued cooperation between the State Highway Commission and the University, the staff of the Joint Highway Research Project looks forward to continued, coordinated, and expanded research on the many difficult problems which are present now and which unquestionably lie ahead.