Status of Large Scale Road Tests

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Since the title of this report mentions road tests in the plural, it is appropriate to say a few words about the first two major road tests that have been conducted in recent years. However, since most engineers that are interested in highways are by now fairly well aware of the earlier tests, the bulk of the report will concern the American Association of State Highway Officials Road Test which is now under way.

The first recent test was conducted by the Highway Research Board for several North-Eastern States in 1950 and 1951. It was a test of an existing concrete pavement under controlled axle loads conducted in Maryland. It was called Road Test One-Md or more popularly, the Maryland Road Test. Some highly valuable data relating to strains in concrete pavement and the behavior of one particular design of concrete pavement on a clay soil were obtained.

From 1942 to 1944 there was a test known as the WASHO Road Test conducted in Idaho for the Western Association of State Highway Officials. This test, also administered and directed by the Highway Research Board, studied the effects of controlled axle loads on specially built sections of flexible pavement. Here again valuable data were collected and some of the findings, particularly those dealing with the effectiveness of paved shoulders and the relative value of 4 and 2 inch asphaltic concrete surfacing, have been used to effect changes in pavement design throughout most of the Western states.

These two tests are now history and comprehensive reports are available at nominal cost at the Highway Research Board offices in Washington for those interested in the details.

AASHO Road Test

Now underway, near Ottawa, Illinois, is the world's largest and most comprehensive highway research project. The idea for the

AASHO Road Test, originally conceived and sponsored by the American Association of State Highway Officials, was born in 1951. Planning has been underway since that time. Like the WASHO Test, its primary objective is to study the behavior of pavements of known thickness and design under dynamic loads of known magnitude and frequency.

The 48 state highway departments, the several territories, the Bureau of Public Roads, the Department of Defense, the Automobile Manufacturer's Association and other industry groups are cooperating in financing the $20 million program. The Highway Research Board of the National Academy of Sciences—National Research Council is administering and supervising the project, as it did the Maryland and WASHO Tests.

Six test loops are under construction in La Salle County, Illinois, about 80 miles southwest of Chicago, an area selected because its climate is considered to be representative of that of much of the nation and its soil similar to that underlying many areas of the country.

Construction of the test loops is well under way, and the present schedule calls for completion during the coming summer. If it proves possible to meet this schedule, test traffic will start next fall and continue for two years. Another year will be required to complete post-traffic studies and to prepare final reports.

The Highway Research Board faced a huge task when it took over administration of the project in 1955. One of the first problems was the assembling of a sufficient quantity and quality of engineering, scientific and administrative talent that could be welded into a cooperative and understanding staff team. This was accomplished and, by the spring of 1956, the project was ready to go forward.

The Board and the project staff have been fortunate to have the advice and guidance of some of the nation's top men in various fields. There is, for example, a national advisory committee composed of 33 outstanding men from state highway departments, the Bureau of Public Roads, the Department of the Army, several universities, and the automotive, trucking, petroleum and rubber industries. This committee has been ably headed by Prof. K. B. Woods of Purdue University. In addition to this group, there are four regional advisory committees composed of representatives from each of the state highway departments.

Another source of tremendous aid has been the several technical advisory panels on statistics, public information, materials and construction, bridge research, soils, instrumentation, maintenance and vehicles. Some of the country's foremost authorities in these fields are serving as members of these panels which meet frequently with the staff to review their activities and plans and to advise them in their respective fields.

The Bureau of Public Roads, the Department of Defense, and the Illinois Division of Highways play a major role in the AASHO Road Test by providing funds, manpower, equipment and/or services. An important administrative feature is that one man in each of these organizations was designated as liaison through whom all Highway Research Board dealings are channeled. E. H. Holmes, Deputy commissioner for research, was designated as representative of the Bureau of Public Roads; D. Kenneth Chacey, special assistant for transportation engineering, as representative for the Department of Defense; and W. E. Chastain, Sr., engineer of physical research, as representative of the Illinois Division of Highways.

Insofar as the states and territories are concerned, their part in financing the project was developed as a contractual agreement between each state highway department and the Bureau of Public Roads. This agreement provides for the Bureau to act as the state's fiscal agent and pay its share of the cost directly to the Highway Research Board. The monies are deducted from the 1½% highway planning survey funds allocated to the states. In addition, the Bureau of Public Roads is contributing money, services and equipment; the Department of Defense is contributing services by furnishing Army drivers for the trucks; and industry is contributing money.

Staff Organization

The staff organization for the project is on a functional basis. The top administrative officers are the project director and the chief engineer for research. Below them are 11 branches, each headed by a supervisor. These are: public information, instrumentation, vehicle operations, construction, maintenance, materials laboratory, special assignments, bridge research, flexible pavement research, rigid pavement research, and data processing and analysis.

The Highway Research Board has secured well-qualified people to man eight of these posts.

W. B. McKendrick, Jr., a former Chief Engineer of the Delaware State Highway Department, was appointed Project Director in April of 1956. William N. Carey, Jr., of the Highway Research Board is the project's Chief Engineer for Research. Dr. Paul Irick, formerly an associate professor of mathematics at Purdue University, is Chief, Data Processing and Analysis. A former staff member of the Bureau of Public Roads, and longtime Chairman of the H. R. B. Flexible Pavement Design Committee, A. C. Benkelman, is Flexible Pavement Research Engineer; and Frank H. Scrivner, formerly of the Texas Highway Department and more recently returned from an assignment in London, England, is Rigid Pavement Research Engineer. Arthur Tosetti, a resident engineer with the Illinois Division of Highways for many years is serving as Road Engineer in charge of construction work; and Rex Leathers, on loan from the Bureau of Public Roads, is Engineer of Special Assignments. Howard Boswell, also on loan from the Bureau of Public Roads, is Maintenance Engineer. Lloyd Mettis, formerly a member of the Staff of the Indiana State Highway Department, was Materials Engineer during the construction work last year. James Shook, former research engineer for the National Sand and Gravel Association and the National Ready-Mixed Concrete Association, is presently Acting Materials Engineer. W. James Schmidt, formerly a member of the staff of the Delaware State Highway Department and later a writer and editor for several newspapers, is Chief, Public Information. Dr. Ivan Viest, formerly associated with the University of Illinois, has recently joined the staff as Bridge Research Engineer.

The National Academy of Sciences established a business office at the project site to handle all business matters connected with the project. This office is under the direct supervision of Peter Talovich.

Layout of Project

In the physical layout of the project there are four main loops (A-D-C and B) each consisting of approximately 13,200 feet of test sections in two-lane roadways connected at each end by a turn-around of 200-foot radius. (Fig. 1.) A fifth loop (E) has 8,800 feet of test sections connected by turn-arounds of 50-foot radius' and a sixth loop (F) has 4,400 feet of test sections connected by turn-arounds of 30-foot radius. The total distance around each of the main loops is 3.1 miles, and the distance around loop E is 1.9 miles.

Traffic will run over five loops (A-D-C-B and E) for a two-year period, but only conditioning traffic and limited amounts of other traffic will be permitted on Loop F.

Half of the test pavements will be rigid type (non-reinforced and reinforced concrete) and the other half will be flexible type (asphaltic concrete).

The project also includes 16 test bridge spans—eight of steel girder construction, four of conventional concrete and four of pre-stressed concrete.

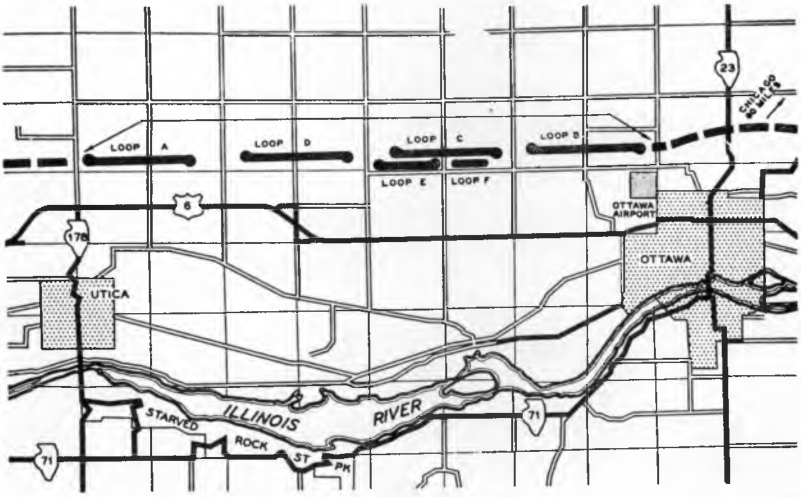

Fig. 1. This map shows the location and the layout of the AASHO Road Test's six test loops near Ottawa, Illinois. This area was chosen for the test site because its soil and climate are similar to that of wide areas of the nation.

The main test loops are so arranged that when testing is completed the turn-arounds can be removed, the tangents connected, and the pavements incorporated into a relocation of nearby U. S. Route 6 as a part of the interstate system.

Construction Operations

The major construction operation at the AASHO Road Test during 1956 was the grading work. A large concentration of equipment was necessary to carry this work forward simultaneously in each of the four main loops. (Fig. 2.) This concept of operation also required similar concentration of manpower, and at the peak of operations, 140 people were associated with the project staff.

Construction control involved as many as 59 engineers and subprofessional people. The Road Engineer had two assistants—one in the office and one in the field. Each loop was under the control of a resident engineer. Each loop resident had at his disposal a survey party under the leadership of an engineer and several technicians to assist in the grading inspection.

A temporary materials laboratory was built in which the extensive testing program was carried on until completion of a permanent administration and laboratory building. At the peak of operations the materials laboratory had 55 engineers and subprofessional people. A total of 30 worked in the laboratory processing soil

Fig. 2. Four types of equipment played major roles in the grading phase of the AASHO Road Test construction. Shown here are a rotary speed mixer (foreground), a pneumatic compactor (right center), and a blade grader and two earth movers (background).

samples; and a testing crew of five, under the supervision of an engineer, collected soil samples in each loop.

Forty-six engineers were directly connected with the project. Fifteen comprised the Illinois task force which has spent the winter preparing plans for 1957 construction. Twelve other engineers were on loan from the Bureau of Public Roads and one, each, came from the states of Ohio, Wisconsin, Iowa, Missouri, Kansas and Oklahoma. The remainder were part of the Highway Research Board staff. It was indeed fortunate that we could have these engineers associated with the project. Eleven had good previous experience in surveying, earth work and/or testing techniques.

Construction work in 1956 included piers for four overpasses which will carry local roads across the test loops. (Fig. 3.) The contracts for steel for these bridges and the test bridges were awarded last May. A contract for two drainage structures was awarded in June.

By far the largest contract was for the grading and construction of the grade separation bridges. This was awarded in July to S. J. Groves and Sons Company and Arcole Midwest Corporation, bidding jointly at a price of $2,025,000.

Fig. 3. Four overpasses carry local roads across the main test loops at the AASHO Road Test. When testing is completed, the main loops will be rehabilitated to become part of US Route 6 in the interstate highway system.

The amount for all work placed under contract was $2,216,061. Additions raised this to nearly $2,700,000—a major addition being a fifth test loop for 2,000-pound and 6,000-pound axle loads. This loop was added after the enactment of the Federal Highway Act of 1956 which recognized the AASHO Road Test and requires an interim report in March of 1959.

Fig. 4. An earth mover places a six-inch lift of soil on one of the AASHO Road Test loops. The A6 type soil was then bladed, mixed, and compacted. Specifications called for density to be controlled between 95 and 100 per cent of standard maximum, and moisture content between plus or minus two per cent of optimum.

Large earth movers placed nearly 1¼ million cubic yards of earth during the grading operations, starting in late August and running till mid-November. (Fig. 4.)

About half of this was placed in the upper three feet of the embankment under controls more strict than ever before attempted in large-scale highway construction. These strict controls were not directed at attaining some sort of super-density in the embankment. Rather, they were directed at what has become a watchword of the AASHO Road Test—uniformity. A high degree of uniformity of embankment support and strength is essential if differences in the behavior of pavement sections are to be correlated with pavement thickness and type.

Material for the embankment was removed from borrow pits adjacent to the test loops. Specifications required that the soil of the upper three feet of the embankment be carefully selected and all of the A-6 group, that compacted density be controlled between 95 and 100 per cent of standard maximum, and that moisture content be controlled between plus and minus 2 per cent of optimum. The soil was placed in "lifts" with a compacted thickness of 4 inches.

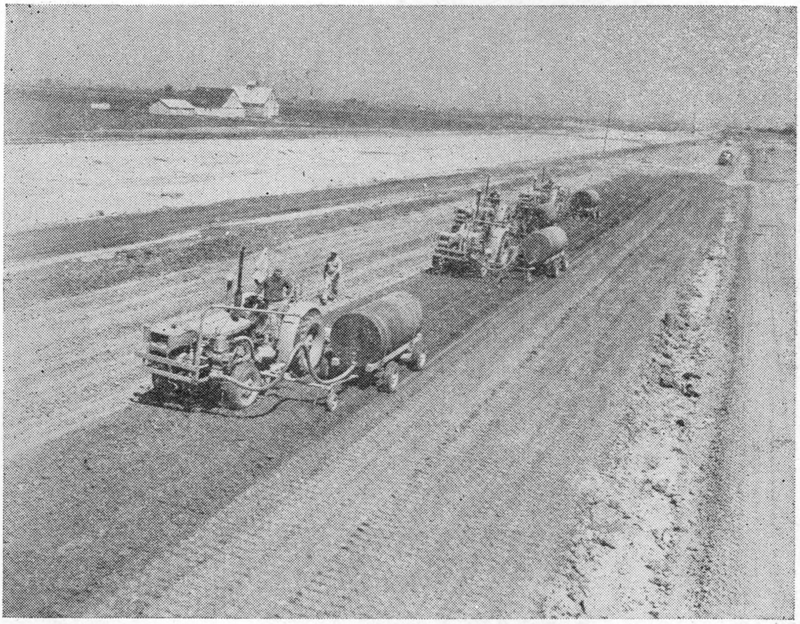

Fig. 5. Rotary speed mixers, working in teams, blended the uncompacted soil and added the proper amount of water before pneumatic compactors went to work. These mixers are working on Loop E. The completed embankment for Loop C is in the background.

All of the grading work was accomplished with conventional equipment. One exception was the use of rotary speed mixers. (Fig. 5.) These machines, working in teams, were used to thoroughly mix the soil and add water in the necessary amount before a lift was compacted.

Compaction was carried out with pneumatic rollers pulled by crawler tractors. Their gross weight was 15 tons. The weight per inch of tire was 425 pounds. Seven to eight passes were required to provide the required density.

The necessity of working simultaneously on all four main loops, plus the requirement that the contractor make every effort to complete the grading by fall, made it imperative that a large amount of equipment be used.

More than 225 pieces of equipment, valued by the contractor at more than $5,000,000 were used during grading operations. Placing the soil in each test loop required from four to 16 four-wheel earth movers of 18 cubic yards capacity. Also required were five to seven rotary speed mixers, two to three pneumatic rollers, two to eight water trucks, one to three blade graders, and numerous miscel-

Fig. 6. Many samples were taken in each compacted lift in the top three feet of the AASHO Road Test embankments to insure close control of the density and moisture content. Here a field density sample has been taken and wrapped in foil for its trip to the Materials Laboratory.

laneous equipment. During maximum operation, this equipment moved 25,000 cubic yards a day.

The entire grading operation was carried out in blocks 500 to 800 feet long, each followed by a 50 to 100-foot transition area. All equipment turn-arounds and cross-overs were made in these transition areas which will not be a part of the test.

Fig. 7. A technician at the AASHO Road Test is shown running experimental tests on a gamma ray device which will be used to determine the density of materials. The test is nondestructive and much faster than conventional density tests.

Testing Operations

The tests used in control of the embankment were conventional in that control was based entirely on attained moisture content and density. (Figs. 6 and 7.) A modified Shelby tubing device was developed by the staff to speed taking of specimens for field density tests. Certain other modifications of testing techniques were necessary so that within 90 minutes of the completion of rolling in any block lift, all tests were run, analyses of the data made and the decision to accept or reject the lift reported back to the field.

In an average block lift this involved taking five samples for 1-point Proctor tests, determining in the laboratory the maximum densities and optimum moistures, field sampling and laboratory testing of 20 field density specimens, and all computations and statistacal analyses. Since more than 20 block lifts were processed each day during peak operations, assembly line techniques were required.

The backbone of the testing operation was a high-speed drying oven, (Fig. 8.) designed by the staff and built locally. It utilized infra-red lamps and an endless chain that carried soil moisture samples through a drying chamber at the rate of about three per

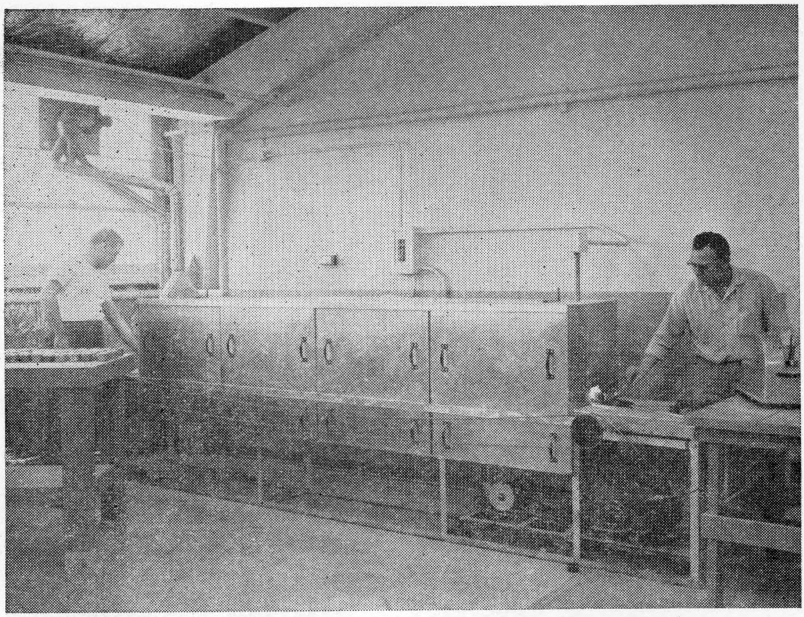

Fig. 8. Assembly-line techniques were used in the AASHO Road Test Materials Laboratory to keep pace with the fast-moving construction operation. This high-speed drying oven was designed by the staff. Using an endless chain running under infra-red bulbs, the oven dried a soil moisture sample in 23 minutes.

minute. Where the conventional type of oven may require several hours for drying, this oven took just 23 minutes.

Another feature of the testing program was the radio dispatching of messenger cars to pick up samples from field crews. The driver of a radio-equipped vehicle received instructions directly from the main laboratory. The laboratory was also able to report the results of tests directly to the field crews.

During construction of the subgrade the number of tests performed by the laboratory staff reached staggering proportions. During the period from late August to mid-November, all types of tests totalled more than 51,000 with a daily average of about 850. In one 13-hour work day, the laboratory completed 1,200 tests of various kinds.

The laboratory staff performed 17,000 density tests, 6,800 compaction tests, 27,000 tests for moisture content, 250 plate bearing tests, and 80 CBR'S.

Since field density samples were secured on a random basis, each square foot of a block lift had an equal opportunity to be sampled. The compaction control was actually much better than anticipated. It was estimated by statistical techniques that, had an infinite number of samples been taken, only 8 per cent of them would have fallen below 95 per cent of maximum density and 14 per cent would have fallen above 100 per cent. The overall mean per cent compaction was 97.9 and the mean standard deviation was 1.71 per cent. The mean range of the actual density values by block lifts was six pounds per cubic foot from the lowest to the highest observed values.

The grading was more than 95 per cent completed when weather forced construction operations to a halt on November 19. About 75,000 cubic yards remain to be placed in the special study and light-traffic loops.

The original plan for embankment construction contemplated the use of a six-inch blanket of sand-gravel mulch. This was intended to serve as a cover for the embankment during the winter and also as a granular subbase. However, some difficulty was experienced in washing the material to meet the exacting specifications for a uniform subbase material, and production was slower than anticipated.

Some of the mulch was placed on loop turn-arounds. However, rather than take a chance that the construction season would end with the mulch cover on only a part of the test loop tangents, it was decided to withhold it entirely. There has been no curing cover on the embankment during the winter, but the contractor will be required to reprocess and recompact the upper layer of the embankment this spring. The moisture content will be brought back to within the specified plus or minus 2 per cent of optimum and the compaction to the specified 95 to 100 per cent of maximum density.

Construction of the main office and laboratory building also went forward last summer. The building is a pre-fabricated steel structure containing 11,400 square feet. All of the project staff, with the exception of the Illinois task force, is now housed in this building.

Construction is under way on a 60 by 100-foot vehicle maintenance building, and bids will soon be asked on quarters and recreational facilities for the Army personnel who will drive the test vehicles. All of these facilities must be ready before the start of test traffic next fall.

Current and Future Operations

The AASHO Road Test staff and the Illinois group face a busy summer in order to complete construction of the six test loops. The longitudinal profile of part of one of the main test loops will serve to give some idea of the complexity of the construction plans.

The project includes 836 test sections. There will be 10 traffic lanes, each to be tested under a specific axle load. These loads will range from 2,000 pounds on a single axle to 48,000 pounds on a tandem axle. Sixty-six vehicles will run on the ten test lanes for about 18 hours a day, six days a week for two years.

Slab thicknesses in rigid pavement will range from 2½ inches to 12½ inches. Sand subbase will be 3, 6 or 9 inches, but a few sections will be laid directly on the basement soil. Half of the concrete slabs will be reinforced and half non-reinforced.

Flexible pavement structure will range from 1 inch to 31 inches. Sand subbase for the flexible pavements will be 4, 8, 12 or 16 inches thick. Crushed stone base will be 3, 6, or 9 inches thick in the main test loops. Some special sections with cement treated base, bituminous treated base and gravel base, some with surface treatment, and others with paved shoulder will be included.

Once the design of the AASHO Road Test had been established and the construction control was underway, the research staff turned its attention to detailed planning for the job ahead. One of their functions has been to see that no measurement or observation will be made unless a specific purpose will be served. The reason for this is apparent when one considers the great amount of data that will be accumulated in this test. If only one observation per test section per week were made, there would be about 90,000 bits of data.

Obviously, more than one reading will be made in each section per week and it is estimated that the staff will be treating hundreds of millions of bits of data in this project. This emphasizes the importance of making a careful evaluation of the types of analyses that will be made. Programs for many of the analyses have already been written for high-speed electronic digital computers, and some of the analyses have been tested by running dummy data through the computers.

Instrumentation

Instrumentation and data reducing equipment costing many hundreds of thousands of dollars will be required, and the staff is working with a sepcial panel of authorities in the instrumentation field to insure the optimum use of project funds in this particular area. Staff members are also consulting with electronics systems engineers. Their function is twofold: first, to assist in the development of transducers and instrument systems that will truly measure what we want; and second, to develop means for electronically transposing data taken in the field to its final form on punched cards or tapes.

The notion should be dispelled that all of this elegant and expensive electronic equipment will measure everything engineers would like to know about what happens within a pavement. On the contrary, it will be making the ordinary measurements such as strain, deflection and roughness, the value of which have already been demonstrated in the correlation of pavement behavior and design variables. The need for the more elaborate equipment in this test is due to the magnitude of the project and the short time available for data analyses and report preparation.

There are really two main classes of measurements that will be made. The first is that which applies to the main objective of the test, that is, the determination of the relationships between the behavior of the different pavement sections and the loads that operate on them. In this class are such phenomena as rutting, cracking, faulting of joints, and longitudinal roughness. The second class of measurement concerns the mechanics of pavement behavior, that is, why does a pavement fail and in what way? Included here are strain, deflection, materials characteristics, temperature, and moisture content.

One of the staff functions has been to develop instruments to measure these things. Some such instrumentation is already available, but, by and large, most of it must be developed for the specific application involved. For example, subsurface temperatures can be measured with thermo-couples that are available commercially but, to date, no device is available with which subsurface soil moisture contents can be measured in a non-destructive determination with a sufficient degree of accuracy. The staff is working on such a device that shows much promise. If it does not prove satisfactory, we shall have to resort to destructive tests in which samples are taken through the pavement for gravimetric moisture content determination.

At the WASHO Road Test, dynamic pavement deflections under moving loads were measured with a device that required the installation of a long steel reference rod under the pavement. It was discovered that the presence of the rod and other necessary parts of the installation affected the behavior of the pavement. Conception and development of a device to determine the profile without inordinate delay to traffic has been perhaps the most difficult instrumentation problem.

The means for treatment of the multitudinous data have been fairly well established. Basically, the concept has been to do everything automatically if it appears economical of time and personnel to do so. A side product of automatic data handling is in the reduction of human error. Slow-moving phenomena, such as temperature, for example, will be observed by technicians who will utilize mark-sense IBM cards to record their observations. The mark-sense cards will then be punched automatically at 100 per minute without the need for keypunch or keypunch operator. High-speed phenomena such as dynamic deflections will be recorded on magnetic tape and electronically analyzed to produce digital information which, in turn, will be automatically punched on IBM cards.

A fairly complete IBM machine set-up will be maintained at the project. Selected data will be automatically transferred to punched paper tape and sent to another laboratory for analysis in the digital computer. In the main studies little or no analog data will be gathered; thus the need for reading oscillograph tapes or film is practically eliminated.

Of course, the staff has no intention of relying entirely on automation. It is aware that engineering common sense has a large place in the scheme of things, and it anticipates that during the course of the test a considerable amount of time will be spent by the research staff in data analysis using desk calculation, slide rules and graph paper. Certainly such analyses will be necessary to provide a constant check on the progress of the tests.

This has been, and will be, a most interesting and provocative project. It is the third and largest road test undertaken by the Highway Research Board for the state highway departments. Drawing upon the experience acquired in the previous tests and supplementing that with the latest thinking in experimental design, the latest developments in electronic instrumentation and data analysis, the project will produce much information that will be invaluable in future highway engineering and highway transportation.