REPORT OF COMMITTEE ON ANTISKID PROPERTIES OF ROAD SURFACES

The Committee on Antiskid Properties of Road Surfaces was reorganized with a new chairman and several new members just prior to the 28th Annual Meeting of the Highway Research Board. During the 28th Meeting the Committee met and set up certain objectives. These objectives and the research program of the Committee were expanded during 1949 as the result of new developments and research in road surfaces of special interest to the Committee. In this report the objectives of the Committee will be outlined together with a statement of the expanded research program and the progress made thus far in the proposed research program.

While skid resistance is one of the most important properties of road surfaces, there are at least six other factors relating to road surfaces which are closely related to skid resistance, to which the highway engineer should give special attention in the design, construction, and maintenance of highways for the safe and economical operation of modern high speed traffic. These six factors are: road roughness, tire wear, tractive resistance, noise, glare and light reflection and electrostatic properties. In the reports given by Committee members during the past twelve years, some notable researches in road roughness, tire wear and tractive resistance have been presented at the annual meetings. No reports of research in road and tire noise, glare and light reflection and electrostatic properties of various types of road surfaces have been given. The lack of reports is an indication of the need for research on these topics.

It should be realized at the outset that it is not possible to build road surfaces which will provide the best possible performance for all of the above conditions. Thus, a surface which is highly skid resistant is almost certain to be an abrasive surface which contributes to a high rate of tire wear. Conversely, the lowest tire wear is obtained on surfaces which are slippery when wet. Also, road surfaces which provide high skid resistance frequently will have excellent light reflecting qualities for night driving, but they may have a coarse open surface texture which causes a "roaring" tire noise, especially at high speeds. This roaring or rumbling tire and road noise is a source of considerable annoyance and irritation to drivers and passengers in cars so affected and may be an important contributing factor in traffic accidents

The public judges a road largely by its smoothness or riding quality. The braking performance, tractive resistance, safety and economy of operation of all vehicles is improved when road surfaces are built with a uniformly smooth surface. Periodic measurements of surface smoothness (or roughness) provide a definite test of the excellence of the design standards and of the construction and maintenance methods used to meet the traffic requirements for a given road in a given location. Highway engineers can profit in many ways by a study of road roughness, not only as a measure of the public acceptability of a given road, but also as a measure of the progressive failure of the road due to heavy vehicles, pavement pumping, frost action, differential heaving, and other traffic and road factors.

It does not appear logical to direct the attention of highway engineers to only one property of road surfaces, however important it may be, when there are other important properties to be considered, and to be correlated in rating road surfaces and in establishing the best possible standards for the design, construction and maintenance of road surfaces. Accordingly, it is proposed that the scope of activity and the objectives of the Committee be enlarged and that its name be changed to "Road Surface Properties Related to Vehicle Performance".

OBJECTIVES OF THE COMMITTEE

On the basis of its enlarged scope the objectives of the Committee, briefly stated, now are:

1. To assemble researches in the measurement of skid resistance, road roughness, tire wear, tractive resistance, noise, glare and light reflection, and electrostatic properties in relation to various types of road surfaces and to determine where additional researches are needed.
2. To encourage organizations, and persons fitted to do so, to conduct needed researches on subjects relating to the study of the above-named subjects, which will lead to the development of uniform standards of measurement and a rating system for each of these factors which may be used in establishing acceptable standards of design, construction and maintenance of the surfaces of various types of roads.
3. To coordinate and bring to the attention of highway engineers and highway users results of researches which will lead to the establishment of acceptable road surface standards based upon the rating system as proposed by the Committee and thus provide greater safety, economy and comfort in the operation of motor vehicles or road surfaces built to these standards.
4. It is recognized that with the enlarged scope of activity of the Committee, its membership should be increased if satisfactory progress in meeting its objectives is to be achieved.

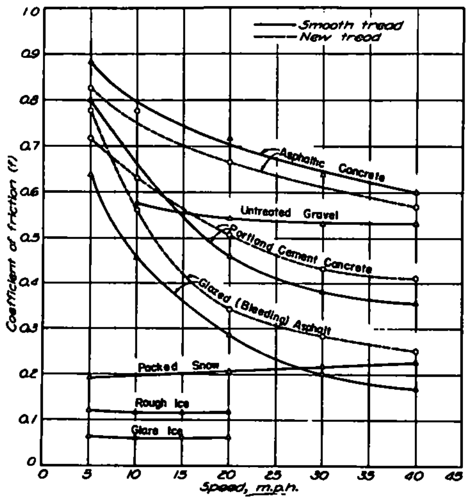

Figure 1. Coefficients of Friction for new Tread and Smooth Tread Tires on Various Types of Road Surfaces in Wet Condition

DISCUSSION OF RESEARCH ON SKID RESISTANCE, ROAD ROUGHNESS AND RELATED PROPERTIES OF ROAD SURFACES

In the following discussion, a brief review of the research on skid resistance, road roughness and related properties of road surfaces will be given. Test proposals for measuring various properties and for establishing standards of measurement and standards of design, construction and maintenance will also be discussed.

Skid Resistance - The earliest reports of research on skid resistance of rubber tires on various road surfaces which gave a true indication of the many variable factors which influence tire and road friction, especially the hazardous slippery condition of certain road surfaces when wet, were given at the Annual Meeting of the Highway Research Board in 1933 by R. A. Moyer, covering the work at Iowa State College, and by Stinson and Roberts, covering the work at Ohio State University.

The most important findings in these two researches are fairly well summarized in Figure 1. In this figure, the slipperiness of typical road surfaces on which tests were run by Moyer is shown in terms of the coefficients of friction at various vehicle speeds from 5 to 40 mph. tor new tires with a non-skid tread pattern, and for smooth tread tires. A significant fact uncovered by this study was that the coefficients of friction for all slippery surfaces, except those covered with snow or ice, were fairly high at low speeds, but dropped sharply as the speeds of the test vehicle were increased. Thus, at a speed of 5 mph. the coefficients for the glazed asphalt surface when wet were in the range of 0.8 to 0.6, but at speeds of 30 to 40 mph., the coefficients for new tread tires dropped to values below 0.3 and for smooth tread tires to values below 0.2, which is in the range obtained on ice and snow, surfaces known by all drivers to be extremely slippery. The seriousness of the hazard created by this characteristic of slippery road surfaces, for which the coefficients of friction decrease with an increase in speed, becomes more apparent when attention is directed to the fact that the friction requirements for such driving operations as acceleration and braking increase approximately as the square of the speed.

In these early tests it was found that the type of tire tread had important bearing on the coefficients of friction. Thus, smooth tread tires developed much lower coefficients on slippery, wet surfaces than tires with a non-skid tread pattern, as shown in Figure 1 for the glazed asphalt surface. On coarse grained surfaces, such as the asphaltic concrete in Figure 1, and on rockchip treated surfaces with an open texture, the coefficients for the smooth tires were higher than for the tires with a non-skid tread pattern. This led to the squeegee theory, which provides a logical explanation for the effectiveness of various tread patterns to develop the measured skid resistance on various types of road surfaces.

All of the research in 1933, and the field observations and studies which have been made since that time, clearly show that skid resistance can be built into road surfaces of any type, that slippery roads exist because of improper construction and inadequate maintenance, and that any road can be made skid-resistant and kept in that condition. Thus, it seems fair to state that a "Slippery Road" sign is a confession of faulty construction and upkeep It is to be regretted that many highway departments still depend on "Slippery Road" signs to warn drivers of a danger which is entirely unnecessary.

An important objective of our Committee is to bring to the attention of highway engineers the extremely dangerous conditions which may exist on highways and city streets where no attention is given to skid resistance measurements and to the correction of slippery road conditions. This is a matter of increasing importance today, because driving speeds are higher than at any time in the past, car registrations are greater (as are the number of cars with smooth tires), and since the end of the war there has been an increased use of asphalt for seal coats and for resurfacing, without adequate controls to prevent over-sealing. Over-sealing (the use of excessive amounts of asphalt) is the most common cause of asphaltic type surfaces being slippery when wet.

Skid Resistance Measurements in Virginia - At the Annual Meeting of the Highway Research Board in 1947, Messrs. Shelburne and Sheppe presented a report on "Skid Resistance Measurements of Virginia Pavements". In this report, published by the Board as Research Report No. 5-B, a relatively simple and inexpensive method of making skid resistance measurements was described. It consisted of stopping distance or braking tests which were made with a light weight car using an electrically actuated detonator connected to the brake pedal which fired chalk at the pavement to determine the point at which braking started. Tests were run on dry and wet surfaces at speeds of 10, 20, 30, and 40 mph.

All of the pavements tested in the dry condition were found to have equally satisfactory skid resistance at all of the test speeds. The design standard for braking adopted by the AASHO was used in these tests. It provided for a max. stopping distance of 113 ft. for a speed of 40 mph. This corresponds to a coefficient of friction of not less than 0.47 at 40 mph. Twenty-seven of the 32 surfaces tested wet were considered to have satisfactory skid resistance. Three surfaces found to be unsafe were rebuilt or resurfaced to provide the necessary skid resistance. Tests made on one surface after the non-skid treatment, showed that the stopping distance on this surface when wet was reduced from 222 to 94 ft. at 40 mph. This large reduction in stopping distance is an indication of the value of the tests and the improvements which can be made on surfaces which need non-skid treatment.

The Committee recommends that State highway departments and cities adopt the method of making skid resistance measurements used in Virginia as a simple and reliable procedure.

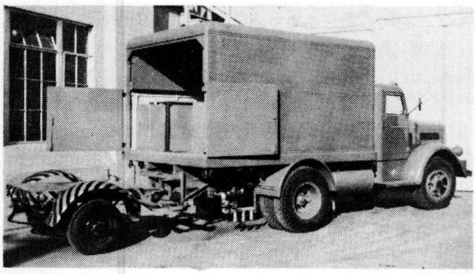

Figure 2. FWD Truck and Trailer Used in Skid Tests

University of California Skid Tests - During the past year, a research project was started at the University of California under the direction of the Chairman of this Committee in which it was proposed to make a study of all properties of road surfaces in California, including skid resistance, which have a bearing on the economy, safety and comfort in the operation of motor vehicles.

In California methods of road surface construction have been developed by the Division of Highways which differ from the methods used in the middlewest and east. The materials used are not always of the same type as the materials used in roads for which published results of skid resistance are available. In the construction of light weight bridge floors, California has adopted an open grid steel decking design. Today there are conflicting reports concerning the skid resistance of this type of bridge floor when wet, largely because measurements of the skid resistance of the various types of open grid steel decking have not been made. From the above it is evident that there is ample justification for a program of tests to measure the skid resistance of roads and bridge floors in California.

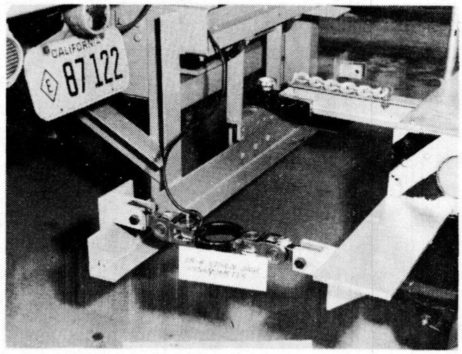

Figure 3. Close-up of Dynamometer under Trailer Hitch

In this testing program, we will measure the skid resistance of various surfaces by the towing-trailer method and in certain locations by the stopping distance method used in Virginia. The towing-trailer method has the advantage that the tests can be run at various uniform speeds, thereby causing a minimum of interference with traffic. This is an important consideration when tests are to be made on heavily traveled roads such as those in California.

In the towing-trailer method, a two-wheel trailer equipped with electric brakes is used. The tow truck is a powerful FWD truck, which can be operated with the brakes applied on one trailer wheel at speeds up to 50 mph. In the body of the truck, there are two large water tanks with a capacity of 170 gal. each. An instrument panel and two work tables have been mounted on the tanks for the various instruments and controls required to measure the braking forces, speed, time and temperature in the braking tests. The water is pumped from the tank to the spray nozzles which are placed in a line directly ahead of each trailer wheel to wet a narrow path on the pavement to be tested. The brakes are applied on only one trailer wheel at a time, since, if the brakes of both wheels were applied at the same time, the drawbar pull required to tow the trailer would be so great that tests could be made only at relatively low speeds. These tests will be made at uniform speeds ranging from 10 to 50 mph. The max. braking force at each speed will be measured with an SR-4 strain gage dynamometer and a magnetic type direct-inking oscillograph.

The truck and trailer with the dynamometer in place is shown in Figure 2. A close-up view of the dynamometer and trailer hitch is shown in Figure 3. The strain analyzer, the two-channel oscillograph recorder, the dynamometer and the speed indicator used in obtaining a record of the braking forces at various speeds are shown in Figure 4.

In the calibration of the dynamometer, it was found that the braking forces can be measured to an accuracy of + or - 2 percent for forces up to 2,000 lb. The most important item in the operation of the direct-inking oscillograph shown in Figure 4 is the magnetic pen motor which provides a uniform response for the maximum recommended amplitude of the pen swing up to a frequency of 70 cycles per sec., which is higher frequency than is required for these tests. The electric brakes on the trailer are operated by an observer in the body of the truck. An Ohmite rheostat is used for accurate control of the braking force, and an electric brake controller is used for quick application. With these controls the maximum braking force can be measured for both the skid-impending (rolling wheel) condition and the locked or sliding wheel condition.

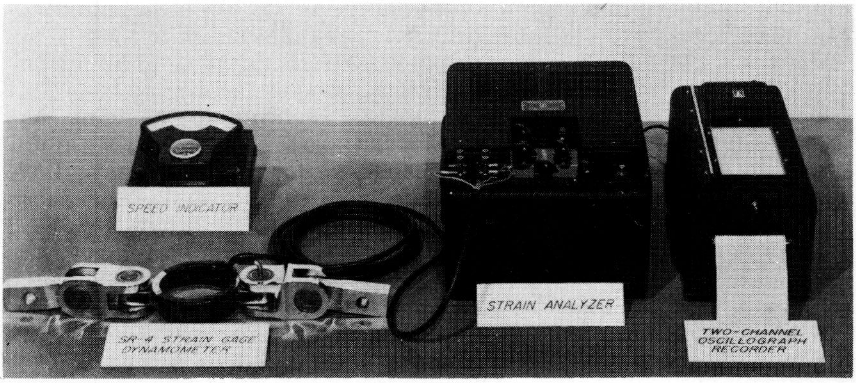

Figure 4. Equipment Used in Measuring Braking Forces and Speed in Skid Tests

In the body of the truck a gasoline motor generator has been installed to provide a 110-volt 60-cycle current with a capacity of 7.5 KVA required to operate the oscillograph, the water pump, lights, fans, and other small items of 110-volt AC equipment.

All of the equipment for these tests has been designed to make possible more accurate measurement of skid resistance and braking forces under various conditions than was possible with any equipment or test procedures previously used by the Chairman in this type of research.

Rubber-Asphalt Test Roads - During the past year test roads were built in Ohio, Texas, and Virginia in which powdered rubber was incorporated in various types of bituminous road construction. By the addition of rubber, it is claimed that the skid resistance and durability of bituminous surfaces will be improved and that they will be less susceptible to temperature change.

Three members of our Committee, Messrs. Allen and Evans of Ohio and Mr. Shelburne of Virginia have taken an active part in these experiments. Reports of this new development in road construction were given at the 1949 Committee meeting by Shelburne and Allen. A paper on the Virginia experiments by Shelburne and Sheppe is included in this Bulletin.

ROAD ROUGHNESS

Road roughness has for many years been recognized by highway engineers as an important factor in the construction of all types of surfaced roads. The use of a long straightedge has been and still is the most widely used method to check surface roughness during the construction of surfaced roads. Since this method does not automatically provide a record of road roughness, and is much too slow for making road roughness surveys, various machines have been developed to speed up the work and to provide automatically a record of the roughness for any desired length of pavement.

The early machines had various defects, the most serious of which was that the results obtained with the different machines were not comparable. In an attempt to overcome the defects of the early machines, the Bureau of Public Roads built the "Road Roughness Indicator" which was described in a paper presented at the Annual Meeting of the Highway Research Board in 1940. This machine provides a quick dependable method of measuring road roughness. It is so designed that it can be exactly duplicated and, to this extent, it is standardizable. Plans for building the BPR Roughness Indicator can be obtained from the Bureau of Public Roads.

Duplicate models of the BPR Road Roughness Indicator were built at Iowa State College and by the Virginia Department of Highways. Extensive tests were made with the Indicator on roads in the middlewest and in Virginia yielding highly satisfactory results. The Indicator built at Iowa State College was acquired during the past year by the University of California. It was completely overhauled and is now being used for making road roughness measurements of various road surfaces in California.

The BPR Road Roughness Indicator is a single-wheel trailer which is towed

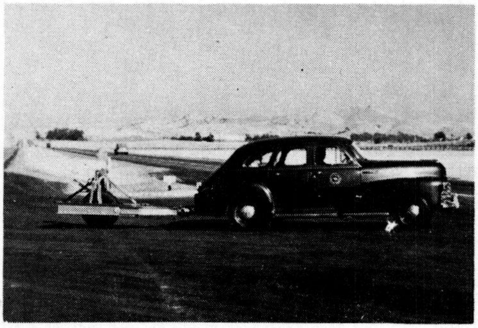

Figure 5. Road Roughness Indicator and Tow Car

by a car or light truck (Fig. 5). A detailed description of the Indicator is given in a paper by J. A. Buchanan and A. L. Catudal, entitled "Standardizable Equipment for Evaluating Road Surface Roughness", published in the 1940 Proceedings of the Highway Research Board. Briefly stated, this machine measures the irregularities in the road surface which are transmitted through a standard tire to the axle of the wheel. The vertical movements of the axle are transmitted by a wire cable to a double-acting ball clutch integrator which in turn transmits the accumulated vertical movements in in. to an electric counter mounted on a board in the tow car. A similar electric counter records the revolutions of the trailer wheel and thus provides an accurate measure of the travel distance. The roughness tests have been standardized at a speed of 20 mph. and the measurements are recorded on a data sheet by an observer for each half mile and at the end of the project. The data are summarized by expressing the roughness of each section of road in terms of a standard unit known as the Roughness Index (RI), which is the roughness in in. per mi.

Experience in the use of the BPR Indicator thus far has led to the adoption of the following tentative standards for evaluating road surface roughness of rural highways:

ROUGHNESS INDEX (in. per mi.)	RIDING QUALITIES
Below 100	Excellent
100 - 150	Good
150 - 200	Fair
Above 200	Rough

On city streets, where speeds do not exceed 35 mph., the above values can be increased 25 percent for each of the four ratings in riding quality.

The California University Road Roughness Oscillograph Recorder - A criticism of the BPR Indicator has been that, in providing the accumulated values of road roughness for a given section of road, it does not give an indication of the type of roughness. Thus, a concrete pavement may have faulting at joints, or it may be badly warped at the joints, while the rest of the pavement may be exceptionally smooth. The roughness values for such a pavement are not likely to be sufficiently higher than those for a concrete pavement without these defects to clearly indicate the poor riding qualities of such a pavement. To obviate this criticism, a special device was developed at the University of California which makes it possible to obtain a graphical record of the road roughness as measured by the BPR Roughness Indicator. This device is attached to the top of the frame of the Indicator (Fig. 6). It consists of a bridge circuit formed by a potentiometer and two precision resistors. A steel tape is attached to the axle of the trailer wheel and to a pulley on the shaft connecting with the potentiometer. A clock spring is used to maintain sufficient tension in the tape so that it follows accurately the vertical movements of the axle and the tire as it rolls over various irregularities on the road surface. The vertical movements of the axle are transmitted to a two-channel direct-inking oscillograph mounted in the tow car. This oscillograph is the same type of unit previously described in this report as being used in the University of

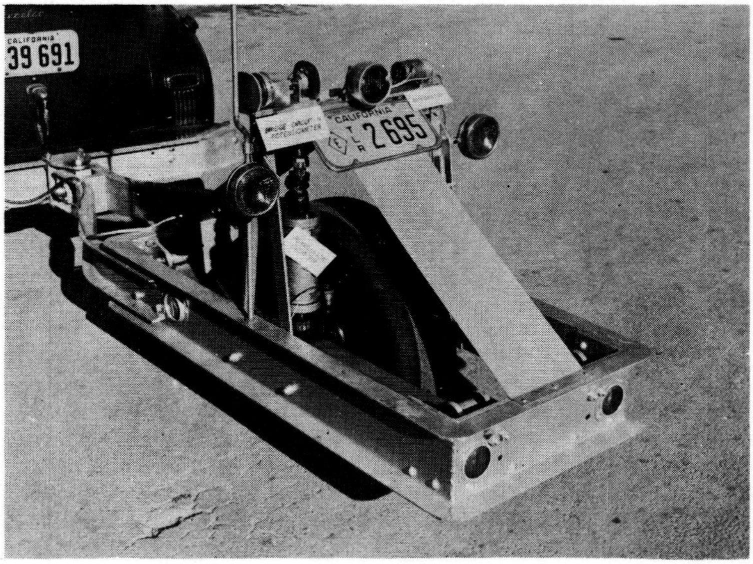

Figure 6. Close-up of Road Roughness Indicator

California skid resistance tests.

The various items of equipment in the tow car required to obtain the oscillograph records of road roughness and the magnetic counters used as erate at three paper speeds - 5, 25, and 125 mm. per sec. The best records thus far have been obtained at the medium speed of 25 mm. (1 in.) per sec. when operating the car and trailer at

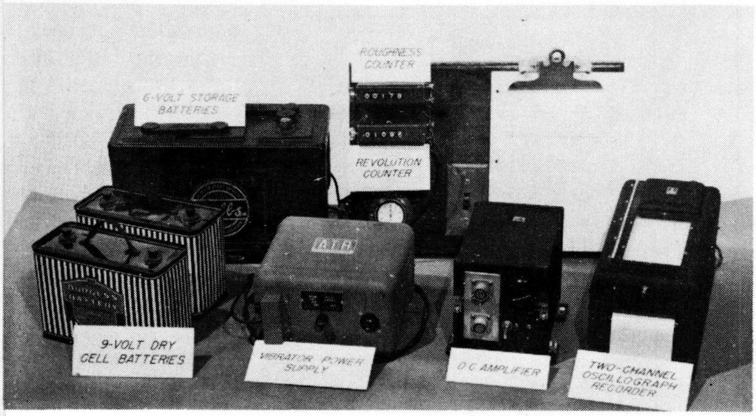

Figure 7. Equipment Used in Obtaining Oscillograph Records and Integrated Values of Road Roughness

standard equipment in this test, are shown in Figure 7. Two six-volt storage batteries are required to provide the current for the vibrator power supply unit and for the DC amplifier unit. The two 9-volt dry cell batteries are connected in series to provide 18 volts to feed the bridge on the trailer. The unbalance from the bridge, developed by the vertical movement of the trailer axle, is transmitted to the DC amplifier and then to the oscillograph recorder. The vibrator power supply changes the 6-volt DC to 110-volt AC required for the motor used to drive the oscillograph chart paper. The DC single-stage amplifier also has a vibration power supply unit to convert the 6-volt DC from the storage battery to 110-volt AC required to operate the oscillograph pen motor.

The revolution counter is tied in with the oscillograph recorder by a direct connection to the pen motor, except that a potentiometer is included in the circuit to reduce the high induced voltage across the pen motor terminals developed by the revolution counter at the break in contact.

The oscillograph is equipped to operate at three paper speeds - 5, 25, and 125 mm. per sec. The best records thus far have been obtained at the medium speed of 25 mm. (1 in.) per sec. when operating the car and trailer at the standard roughness test speed of 20 mph. For these speeds of paper and car, the horizontal scale of the record on the paper is 1 in. = 30 ft. The equipment was designed to provide a vertical scale on the paper of 1 in. = 2 in. These scales are sufficiently large to give the desired detail and accuracy in the record without requiring an excessive amount of paper.

Typical oscillograph records obtained for various concrete and bituminous pavements and for certain special test conditions are shown in Figures 8, 9, and 10. The roughness index (RI) values for the half-mile sections on which these records were obtained are also shown on the records.

The oscillograph record at the top of Figure 8 shows the remarkable smoothness of a section of concrete pavement on US 40 in California on the Fairfield By-pass where the roughness index over a half-mile section was found to be 56 in. per mi. According to the published records of road roughness with the BPR Indicator this is by far the smoothest section of concrete pavement on record. The previous low value for concrete pavements was 78 in. per mi.

obtained on a pavement in Missouri in tests reported in the 1942 Highway Research Board Proceedings.

The low value of 56 in. per mi. was obtained on a section of pavement built superior to methods used in the other States where roughness tests with the BPR Indicator had been run. Observations of the concrete paving operations on the Oakland Freeway indicated that

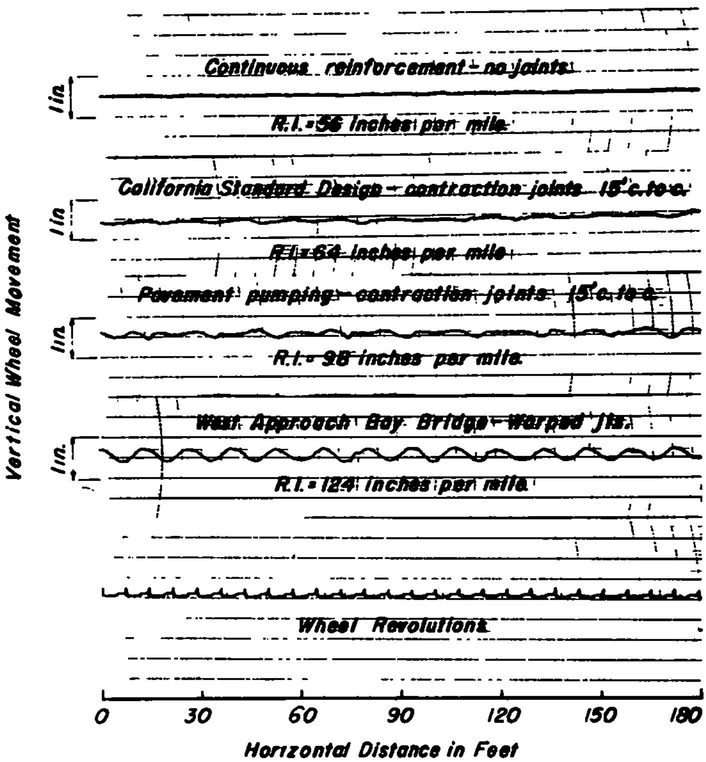

Figure 8. Roughness Oscillograph Records for Concrete Pavements

with continuous reinforcement with no transverse joints. The omission of transverse joints, however, was not the only reason for the low roughness of this section of pavement as is evident from the low index of 64 in. per mi. obtained on the concrete pavement with construction joints spaced 15 ft. on centers on the Oakland Freeway, for which an oscillograph record is shown in Figure 8.

Tests with the BPR Roughness Indicator on more than 50 mi. of concrete pavement in California gave consistently low values. It was apparent that with such low values the California Division of Highways had developed a method of finishing concrete pavements which is the key to building smooth concrete surfaces was largely in the skillful use of the Johnson Finisher developed in California about 15 years ago. Credit for developing high standards of surface smoothness in California should also go to Mr. F. N Hveem, Materials and Research Engineer and to Mr Earl Withycombe, Construction Engineer, both of the Division of Highways, who have been checking road roughness and keeping extensive records of road roughness of the pavements built in California for more than ten years.

The third oscillograph record in Figure 8 shows an oscillogram taken on a section of two-lane concrete pavement subject to pumping on US 40 south of

Fairfield, California The faulting at the joints spaced 15 ft. on centers is clearly evident in this record. The roughness index of 98 in. per mi. appears to be considerably higher than for the smooth pavements shown in Figure 8, yet according to the tentative standards of roughness using the BPR Indicator, this pavement would be given index for this section was found to be 124 in. per mi., which, according to the tentative standards, would indicate that this pavement has good riding qualities. Actually the surface has a smooth surface finish and it is only the warped joints which give it the index of 124 in. per mi., an above average value for concrete pavements. For this case,

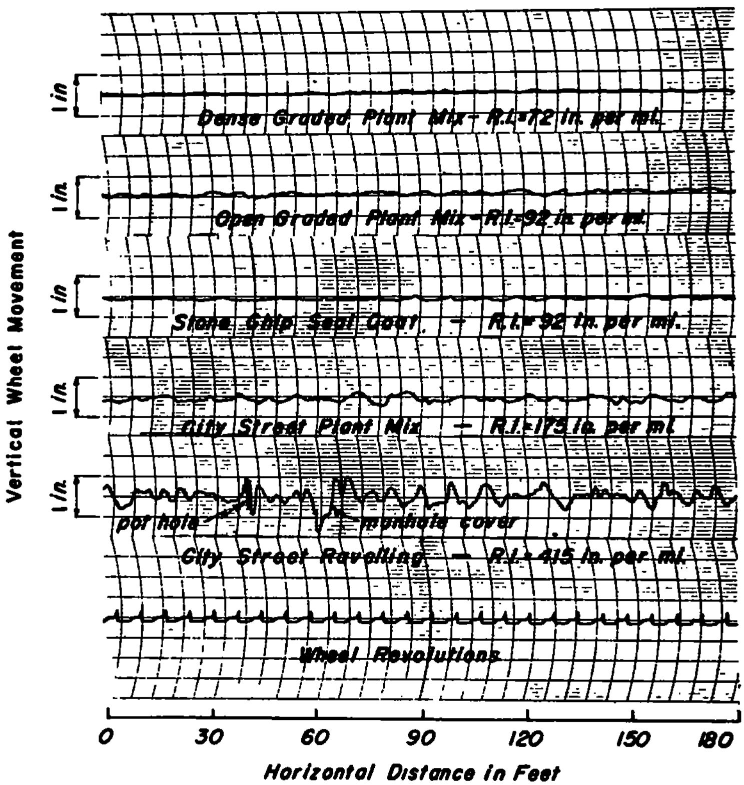

Figure 9. Roughness Oscillograph Records for Bituminous Pavements

a high rating. Careful examination of the oscillogram for this pavement indicates that the pavement is smooth between joints, and that it is only the faulting at the joints due to pavement pumping which has raised the roughness index to 98 in. per mi.

The oscillogram for the concrete pavement on the west approach to the San Francisco - Oakland Bay Bridge provided an interesting record, since this pavement also has a smooth surface finish but it is badly warped at the joints spaced 15 ft. on centers. The roughness the oscillogram gives a better indication of the riding quality of this pavement than the roughness index, because it shows the smooth sine wave produced on this type road surface, which is responsible for the rythmic bouncing ride experienced when driving passenger cars over it at speeds above 35 mph.

Typical oscillograph records of the roughness of bituminous pavements are shown in Figure 9. While the values of road roughness are higher for the bituminous pavements than for the concrete pavements, the oscillograms for the top three surfaces clearly indicate that these surfaces are remarkably smooth. The value of 72 in per mi. obtained for the dense graded plant mix surface on the East Shore Freeway, which carries very heavy truck traffic, is evidence of excellent bituminous pavement design and construction. While these values for the roughness of bituminous pavements are low, it is carefully controlled to obtain the extremely smooth surfaces which the results of these tests indicate are being built in Virginia and California

The oscillograph records for the city streets shown in Figure 9 are fairly typical of the roughness of city streets where the construction and maintenance methods do not measure up to the high standards required by State highway

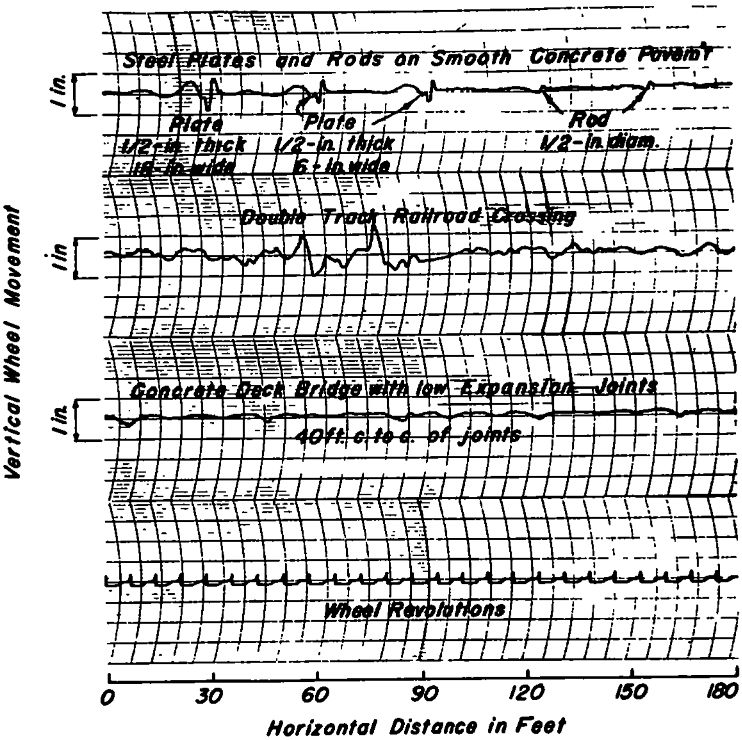

Figure 10. Roughness Oscillograph Records for Special Conditions

significant that in 1948 Mr. Shelburne reported a minimum value of 62 in. per mi. for a bituminous concrete pavement in Virginia. In searching for an explanation for the low roughness values obtained on bituminous pavements in California and in Virginia, it is believed that the answer lies in the use of plant mix materials and a well-designed asphalt pavement finishing machine. Of course, bituminous pavements require a stable base, a well-designed mix, proper compaction, preferably with a three-axle roller, and every step in the plant and placing operations must be departments. While it is true that, since the speeds are slower on city streets than on rural highways, it is not necessary to have as high a standard of road roughness for city streets as for rural highways; nevertheless, when the roughness of a city street reaches the high value of 415 in. per mi. shown in Figure 9, it should be evident that such a street is due for reconstruction or resurfacing. It may be worth mentioning in this connection that one of the best methods which engineers can use for rating road surfaces is in terms of the roughness index Such a rating plan should be very useful in establishing priorities for resurfacing city streets when combined with traffic counts for the streets under consideration.

The three roughness oscillograph records for the special conditions in Figure 10 clearly show the action of the tire and the spring suspension of the BPR Roughness Indicator as it rolls over steel rods and plates of known dimensions, a railroad crossing and a concrete deck bridge. It should be noted that the 1/2-in. diameter rod causes only a ripple in the surfaces as the tire rolls over it, since the wheel rises only about 0. 2 in. when it strikes the rod. There is no indication of a bouncing or vibrating effect after it strikes the rod, which is evidence of the excellent damping action of the dash pots. Since the rise of the wheel is less than half of the thickness of the rod, it is evident that the tire is deformed by the rod and thus contributes to the damping action. When the tire rolls over the 6-in. plates, it is deformed only slightly and is raised almost the full 1/2-in. thickness of the plates. When the tire drops off the end of the plates, it deforms by an amount almost equal to the thickness of the plates. This is followed by a single bounce which is immediately damped out by the dash pots.

The oscillogram obtained when the Indicator crossed a double track railroad crossing shown in Figure 10, gives an indication of the action of the trailer for a condition which is fairly typical of the road roughness at railroad crossings. The oscillogram obtained on the concrete deck bridge shows the action of the trailer as it passed over some low transverse contraction-expansion joints with a 40 ft. spacing. At each joint there were two steel plates six in wide with a groove approximately one-half in wide between the plates. The pattern obtained in this oscillogram gave a clear indication of this particular surface condition and thus gave added support to the accuracy of the records obtained with this equipment.

STUDY OF TIRE WEAR, TRACTIVE RESISTANCE, NOISE, GLARE AND LIGHT REFLECTION ON VARIOUS ROAD SURFACES

The Committee recognizes that tire wear, tractive resistance, noise, glare and light reflection are important road surface factors which deserve careful study and that the results of such studies should be correlated with the results of studies of skid resistance and road roughness. In view of the research now being conducted by various members of the Committee and that which other persons or organizations may be encouraged to do as a result of this report, the prospects appear very favorable for some excellent reports covering all properties of road surface at future annual meetings.

ACKNOWLEDGMENTS

In the research at the University of California described in this paper, the Chairman has been ably assisted by Messrs. Gale Ahlborn, John R. Jones, Louis Possner and John Shupe in the construction of test equipment and in running the road roughness tests. Mr. J. R. Hall, Electronics Engineer and Mr. R. G. Newcomb, Senior Laboratory Mechanic, designed and built the SR-4 strain gage dynamometer, the road roughness recorder equipment, and certain other items of test equipment.

The Chairman also wishes to acknowledge the cooperation of the Division of Highways in helping to arrange for running the tests on new sections of pavement and Mr. Earl Withycombe, Construction Engineer, for his suggestions and interest in conducting the road roughness tests.