DEPARTMENT OF DESIGN

C. N. CONNER, *Chairman*

REPORT OF COMMITTEE ON ANTI-SKID PROPERTIES OF ROAD SURFACES

GEORGE E. MARTIN, *Chairman*

SYNOPSIS

The skid resistance of 36 representative Oregon pavement surfaces was determined by means of a specially constructed trailer towed behind a light truck. A dynamometer in the towing bar measured the tractive resistance of the trailer with one wheel locked, while the trailer was being towed at one of the several constant speeds used in this investigation. Four general types, portland cement concrete, asphaltic concrete, bituminous macadam, and oil mat, were tested. Ages of pavements ranged from 18 years to those not yet opened to general traffic. Surface texture varied from overly fat asphaltic concrete to new heavily grooved portland cement concrete and coarse open textured asphaltic concrete and bituminous macadam.

Tests of the length of skid with wheels locked of a sedan on eleven types of pavement surface in Cleveland, Ohio, are also reported. The standard hydraulic brakes on the car were arranged for air operation, and the length of skid was determined by pistol shot marks on the pavement.

For several years the Committee has advocated the routine use of machines for testing the skid resistance of pavements by state highway departments, municipalities, and other organizations in charge of highways. Recently the State of Oregon ran a number of tests using a machine similar to that described by Professor Moyer[1] on typical pavement sections in Oregon.[2] The Committee presents herewith a description of the methods used in Oregon and the extent of the experimental work.

OREGON SKIDDING TESTS

This is a preliminary report on the skid resistant characteristics of a group of 36 representative pavement surfaces on the Oregon highway system. The pavement surfaces tested include four different general pavement types: portland cement concrete, asphaltic concrete, bituminous macadam, and oil mat surfaces.

The pavements range in age from those laid in 1920 to new pavements laid in 1938 and tested before being subjected to highway traffic. A wide variety of surface textures is included in the test series, ranging from the polished surfaces of overly fat asphaltic concrete pavements, where bleeding of the asphalt has covered the entire surface with free asphalt, and old portland cement concrete pavements worn by seventeen years of traffic, to the new, heavily grooved portland cement concrete pavements and the coarse and open-textured asphaltic concrete and bituminous macadam surfaces.

The tests were made with a specially constructed trailer towed behind a light truck. A dynamometer was placed in the towing bar to record the tractive resistance of the trailer. The tests were made by locking one wheel of the trailer while a constant speed was maintained by the towing vehicle. The tires used were 5.50 by 17 in. retreaded to give a smooth surface without tread design.

Tests were run at constant speeds of 10, 20, 30, and 40 miles per hour on level

[1] *Proceedings*, Highway Research Board, Vol. 13, p. 123. (1933).

[2] Technical Report 39-5, Oregon State Highway Department.

sections of highway under both wet and dry conditions. The results shown are the average of at least four tests. Test data in all cases are reported as coefficients of friction. For tests on surfaces in the wet condition, a sprinkling tank truck was driven ahead of the test vehicle.

The main series of tests was made with a wheel load of 800 lb. which corresponds closely to the wheel load of the average passenger automobile. To correlate the tests with the work of other investigators and to bring out the effect of varying wheel loads, the tests were repeated on a few surfaces using a wheel load of 400 lb.

Three of the pavement surfaces on which tests had been made near the end of the summer season when dirt and oil from traffic had accumulated were retested after a period of several weeks intermittent rain. These few tests indicate the effect of surface cleanliness.

In general the tests confirm the actual driving experience that any of the pavements are satisfactory at reasonable speeds and under dry conditions. At high speeds and with wet surfaces a wide variation in skid resistance was observed. The smooth and so-called sandy-textured surfaces having coefficients of friction when dry of between 0.40 and 0.60 drop to values in the range of 0.20 to 0.30 and in a few cases to below 0.20. The coarser-textured surfaces such as the heavily broomed portland cement concrete, the open type asphaltic concrete, and the newer type bituminous macadam are only slightly affected by water. It was found that the surface textures which permit the draining away of water without flooding the surface are more skid resistant when wet than when dry.

The decrease in skid resistance with increasing wheel load was found to be an important factor especially on dry surfaces. Doubling the wheel load resulted in a decrease in the coefficient of friction of from 25 to 40 per cent on dry surfaces and from 15 to 25 per cent on wet surfaces.

CLEVELAND TESTS

The following description of the work done in the City of Cleveland was presented by Mr. K. H. Rudd of the Standard Oil Company of Ohio.

A 1938 Buick Century four-door sedan was equipped so as to air operate the standard set of hydraulic brakes. The equipment used was manufactured by the Midland Steel Products Company, Cleveland, and was installed by the L. O. Halverstadt Company according to Midland engineers' recommendations.

The set-up is as follows: A 4¼ in. by 3½ in. main air cylinder (part N3050) was rigidly mounted in a steel framework in alignment with the 1⅛ in. diameter hydraulic cylinder supplied with the car. When this was done, the oil cylinder could be actuated to the full extent of its travel by the air cylinder instead of by the foot brake pedal. To control the quantity or pressure of air admitted to the main air cylinder, two valves were used. One was mounted so as to be operated by the brake pedal and the other by a hand lever directly under the steering wheel. The foot valve (part N2111) was of the full compensating type which permitted gradual applications and releases. The hand valve (part N2185) was of the quick opening type and was operated by a high left cam. Either hand or foot valve could be operated independently of the other. The total braking effort was not changed in any way as the original shoes and hydraulic cylinders are still being used in all four wheels.

As the compressor and main air storage system are used for other purposes at pressure of 135 lb., it was considered advisable to use a pressure regulator in connection with the brake operation so as not to cause excessive pressures on

flexible tubing, fittings, wheel cylinders, etc. This made it possible to regulate the maximum pressure to the main air cylinder by fully opening either hand or foot valve and thereby the maximum braking effort could be regulated at will. It was found that a 50 lb. air cylinder pressure was sufficient to lock all four wheels when traveling at ordinary test speeds. The above installation permitted the operation of the braking system in a uniform manner on every test entirely eliminating the human element.

A Projec-tell Meter, purchased from Triangle Associates, 1033 Cathedral Street, Baltimore, Maryland, was also installed on the Buick Sedan. This apparatus automatically and accurately marks the pavement the instant the operator begins the braking process.

This pavement marking device consists of a properly housed revolver loaded with paint pigment cartridges which is fired by an electrically energized mechanism actuated by a contact switch attached to the braking system.

The revolver is fired and an accurate measurement is made from this mark on the road surface to the point (in the same line with the normal progress of the motor car) directly underneath the revolver at the end of the skid.

To similate conditions which the average driver meets, tires which had been driven approximately 8,000 miles, with the tread completely worn, were used. Streets selected for examination were flushed thoroughly by a regular sprinkling truck just before each series of three tests. The sprinkling was extended over a sufficient area to allow the tires of the car to become thoroughly wet before the brakes were applied.

The results are given in Table 1.

TABLE 1

CLEVELAND SKID TEST DATA

Tests Run November 1, 1939

(On Wet Pavements)

Location	Type pavement	Average skid			
		20 m.p.h.		30 m.p.h.	
		Ft.	*In.*	*Ft.*	*In.*
Lakeshore Drive, E. of 53rd	Asphaltic concrete, Ohio T-35.	17	0	36	7
Lakeshore Drive, Btwn. 49-53rd	Asphalt penetration macadam.	17	3	38	4
Buckley Blvd., W. 38	Roughened portland cement, concrete	18	0	48	7
Lakeshore Drive, Btwn. E40-49	New sheet asphalt	19	8	49	11
New Maine Ave., High Level Bridge.	Six-inch steel squares filled with cement concrete	20	4	46	8
Wallworth Run, E. of Fulton	New brick filled with cement grout	20	5	46	0
Madison Ave., W. 71st St.	New brick-asphalt filler— Excess filler removed	21	5	50	3
Buckley Blvd., W. 38	Portland cement concrete treated AE—surface covered with asphalt emulsion for curing purposes	24	3	62	0
W. 51st Train and Clark	Old brick-cement grout filler	27	2	65	2
Superior Ave., E. of 26th	Red medina block-cement grout filler	34	3	90	0
Wallworth Run, W. of Fulton	Old brick-asphalt filler—Excess of asphalt on surface	46	0	108	8