

Tests should not be confined to road-metal. Our many and varied gravels should be tested and classified according to their value for roadmaking, as for many, many years gravelled surfaces will form the greatest portion of our improved highway system, as it does in the United States to-day. Gravel is subjected to abrasion tests, washing and elutriation tests, and grading tests.

Modern research tends to show that the amount of water used in mixing concrete has a vital effect on its future strength. To enable the consistency of a mix to be somewhat standardized the slump test has been devised. The test consists of carefully filling a conical frustum-shaped mould of galvanized iron (4 in. top diameter, 8 in. base diameter, and 12 in. in height) with the freshly mixed sample of concrete, and after leaving it stand for three minutes the mould is withdrawn. The difference between the height of the mould and the height of the concrete mass after it has "slumped" is the measure of the consistency. This difference should not be more than 1 in., nor less than $\frac{1}{2}$ in. for proper consistency.

In addition to the slump test, the flow-table test has been devised, also to measure consistency.

Recently a penetration test for determining the work ability of concrete has been brought into use by the Bureau of Standards, Washington.

BITUMINOUS MATERIALS.

Under this general heading I include tar and tar products, petroleum products, and natural asphalts. Tar and tar products are rapidly losing ground in the field of highway-construction. The overproduction of asphaltic base petroleum products particularly in the Californian fields has so reduced the price of oil asphalts that the use of tar, with its shorter life and other detrimental qualities, is now seldom heard of in the United States. Oil asphalts are also finding great favour in England. The most modern methods of gas-production result in inferior tars, and this factor in addition is tending to increase the popularity of asphaltic petroleum residuals.

As it is likely that by far the greater portion of the mileage of improved surfaces on our highways will involve the use of oil asphalts rather than tars and natural asphalts I will confine my remarks to this class of materials.

The chief feature of bituminous materials as far as the highway engineer is concerned is the consistency. The consistency is tested and designated in three different ways according to whether the material is very liquid, moderately liquid, or semi-solid. In the first case the viscosity is determined by means of the Engler viscosimeter. The viscosity may be recorded in seconds, or it may be recorded as specific viscosity—that is, the viscosity of the material as compared with that of water. This test is used for tars and liquid petroleum residues suitable for use as dust palliatives. In the second case the consistency is determined by the float test. This test is recorded in seconds, and is used in classifying heavy refined tars and asphaltic oils suitable for sealing road surfaces and fluxing solid bitumens. For the third class of material the consistency is determined by the penetration test. This test is recorded in hundredths of a centimeter, and is used in classifying oil asphalts suitable for the construction of bituminous macadam (penetration method), bituminous concrete, and sheet-asphalt pavements.

There are three chief factors to be considered in determining the correct consistency of a suitable product for any job: (1) The method of construction; (2) the climatic conditions; (3) the nature of the traffic which the improved road is expected to take.

The following tabulation shows the recommendations of the Asphalt Association of America:—

Penetration Limits for Asphalt-cement.

Type of Pavement.	Traffic.	Temperatures.		
		Low.	Moderate.	High.
Bituminous macadam	Light	120-150	90-120	80-90
	Moderate	90-120	90-120	80-90
	Heavy	80-90	80-90	80-90
Bituminous concrete	Light	60-70	60-70	50-60
	Moderate	60-70	60-70	50-60
	Heavy	50-60	50-60	50-60
Sheet asphalt	Light	50-60	50-60	40-50
	Moderate	50-60	50-60	40-50
	Heavy	40-50	40-50	30-40

For most places in New Zealand the figures in the "Moderate temperature" column are suitable.

I have heard complaints in New Zealand that it is sometimes difficult to get bitumen to adhere directly to a dry clean surface. I believe that an investigation of these cases will disclose that a bitumen of a penetration of something less than 150 has been used. In the United States it is not customary to use for sealing purposes any bitumen which is viscous enough to be classified by the penetration test. If for the first coat a fluid bitumen or liquid asphalt is used which when tested will show a specific viscosity at 100° C. of not more than 60 I am sure the above trouble would not be experienced.