ROAD METALS.

The rapid advance of late years towards more perfect highway requirements has resulted in road metals and their study becoming an important branch of highway engineering. W. A. McLean, Provincial Engineer of Highways for Ontario, in his report to the government for the year past dealt with the subject as follows:—

Road metal, in the construction of macadam and gravel roads, serves three important purposes. It distributes the concentrated wheel load over a greater area of sub-soil; it forms a waterproof covering to protect the sub-soil from the softening effects of moisture; it forms a hard and durable wearing surface. The depth of material used, the method of placing it on the roadway, and the quality of materials used, should be proportionate to the three main factors stated. The concentrated wheel load controls largely the depth of material to be used; the necessity of having a waterproof coat emphasizes particularly the method of placing the road metal; and the need for a hard and durable covering is met principally by the quality of stone selected.

The foregoing rule is general, and while a greater depth of material makes a more waterproof surface, and will wear longer than will a thin coat; and while certain qualities of stone have better binding qualities, are more waterproof and will distribute the load at a wider angle, yet in a broad way the three requirements are responded to in the manner stated, viz., distributing power—depth of material; waterproofing—method of applying; durability under wear—quality of material.

Distributing Power—Depth of Material.—When a wagon carries in all two tons, it is apparent that each wheel places on the roadway, along a line which is the width of the wagon tire, a load of 1,000 pounds; if the wagon and its load weigh four tons, the concentrated load on a line the width of the wagon tire is 2,000 pounds. This may be assumed to be communicated to the roadway through a single cube of stone two inches square.

Experience shows that from this cube on a well consolidated roadway, the weight is distributed at an angle of about 45 degrees; and it may be shown that the area of sub-soil over which the load is distributed, is equal to a square the side of which is twice the depth of the stone.

The supporting power of soil may be instanced by an extract from the Ontario Standard Specifications for Concrete Bridges, in which the bearing strength of soils, under foundations, is stated as follows:—

Rock in thick beds	25 tons per square foot
Strong gravel and coarse sand, dry..	8 tons per square foot
Compact sand or film clay, dry.....	4 tons per square foot
Clay, moderately dry	2 tons per square foot
Clean, dry sand, not cemented.....	2 tons per square foot
Wet clay	1 ton per square foot
Quicksand and wet, yielding soils	0 to ½ ton per square foot

While the foregoing may be accepted as a safe guide for the depth of stone under heavy foundations, yet underneath a roadway, in which the protection from moisture is always insecure, safe loads under the macadam should not, with a proper factor of safety, be taken as exceeding one-half the amount stated.

From this analysis of the case, the importance of thoroughly draining the sub-soil becomes apparent; particularly with a view to securing the greatest possible strength of soil at the time of greatest danger, which is during the spring thaws and freshets. It becomes apparent also why four inches of stone placed on a strong, dry, gravel sub-soil may be as effective and durable as 12 inches of stone placed over a wet, slippery and poorly drained clay; and why a Telford or other strong foundation is at times essential over such a clay, and over a soft and marshy sub-soil. It explains why, in a given mile of road, the depth of stone and character of foundation may be varied half a dozen times to secure a roadway of uniform strength throughout the entire length.

Waterproofing—Method of Placing Stone.—A waterproof covering is one of the important features of a good macadam road, and this is largely obtained by the method of placing the stone. This requires a certain depth of material, not less than four inches on the strongest sub-soil, sufficient bonding material, which in waterbound macadam should be stone screenings; thorough consolidation by rolling, and a proper camber to shed water to the side gutters or drains

The depth of metal must in the first instance be proportioned to the strength of sub-soil and the concentrated wheel load, but a minimum depth of four inches is essential as that is the least depth that can be properly bonded by rolling.

Loose broken stone has about 50 per cent. of voids. If laid loosely on the road, without rolling and bonding, it will not shed water; but is merely a sieve through which rain and melting snow pass. The sub-soil is at once softened by moisture, and into this mud, the broken stone is forced by traffic, rutting the road and wasting the stone. To prevent this condition, sufficient fine material should be used on the road to fill the voids for some depth from the surface, and then rolled to thoroughly bond the stone, leaving a smooth water-tight surface from which rain is at once shed to the gutters.

Rolling takes an important place in making a water-tight surface. If not rolled, much damage to the road results before the metal becomes bonded by traffic, a considerable amount of the loose stone is driven into the mud and is largely wasted. Many gravel and stone roads in Ontario have had two or three feet of metal placed on them and forced into the mud in this way. With the voids filled with earth, the stone is of little use other than to strengthen the foundation in an inferior way. Economical construction requires a road crust of well-bonded stone laid in a well defined and uniform layer.

The camber of the road surface should be in keeping with the quality of the stone, and methods of construction. An average crown of one inch to the foot from side to centre is often specified, and this applies to the class of road ordinarily built in Ontario. This will provide for some settlement after construction. Except in the most expensive type of construction a new road should be given a crown that is too high, otherwise it will soon become too flat under traffic. It follows that in maintenance, the surface should be kept smooth and free from ruts and wheel-tracks in order that the flow of water from the surface will be immediate, and that none will have time to soak into the road.

Broken stone should be separated into grades according to size, the coarser stone to be placed in the bottom of the road and the finer at the top. This grading of stone is done by means of a rotary screen attached to the crusher. If the stone is placed in the road without being graded in this manner, the smaller stones wear away more rapidly than the larger and a rough surface results. Large stones at the surface, moreover, are more apt to become loose, to roll under the horses' feet or the wheels.

For common country roads using limestone, there should be placed in the roadbed: