they are evidently needed most, in low-lying sections, where water is seen to remain longest on the surface in the spring or after a heavy rain, where springs have a tendency to appear, or where the ground is found to be cold and wet during the summer.

The name "macadam" is commonly applied to any road surfaced with broken stone, and in this respect is a very unfortunate misnomer. It is the neglect to provide a dry subsoil that is the greatest cause of the unfortunate condition of roads throughout Canada to-day. Roads which are not well drained are but a repetition of the English roads as they existed before the time of Macadam—they are the roads which the system of Macadam displaced. A roadbed in which sub-drainage is not sufficiently provided is the opposite of a macadam road.

The importance of drainage cannot be too thoroughly impressed. Clay in thick beds, when dry, will support from four to six tons per square foot of surface, according to the quality of the clay. If but moderately dry it will support from two to four tons only per square foot of surface. If the clay is wet and soft it will yield to almost any load. Gravel, if well compacted, forms a much stronger roadbed, is less yielding to the action of moisture, and for this reason, even for a thin surface coating, strengthens the road somewhat. But the real strength of the road must lie in the subsoil. Vegetable mould and alluvial soils are weak, having a sustaining power of only one-half to one ton per square foot, and for this reason it is well to remove such soils, securing, if possible, a gravel, clay or sand foundation.

A dry subsoil becomes of greater necessity in a cold and humid climate, such as prevails throughout Ontario for a considerable portion of the year. The injury done to roads by frost is caused entirely by the presence of water. Water expands on freezing, and the more there is under a road and above the frost line, the greater is the injury. In freezing, the particles of soil in immediate contact with the water are first compacted. When room for expansion ceases within the body of the soil itself, owing to its saturated condition, the surface is upheaved. When thawing takes place the subsoil will be found honeycombed, ready to settle and sink beneath traffic. It is, therefore, of the utmost importance that the soil should be relieved of all water of saturation as quickly as possible by under-drainage. The impassable condition of the roads during spring, often axle-deep with mud, is to be attributed very largely to a wet subsoil which has been honeycombed in this manner.

The making of a strong foundation thus resolves itself largely into a question of under-drainage, and the means whereby under-drainage is obtained must be adapted to the manner in which water finds its way under the road, and the nature of the soil. A soil retains in its texture, by capillary attraction, a certain amount of water. In the case of a plastic clay soil, which will absorb nearly one-half its weight and bulk of water, the water retained in this way may be the cause of injury. In the case of gravelly, sandy or other porous soil, it is necessary to remove only the water held by hydrostatic pressure in the foundation of the road. The effect of this is, that with a clay subsoil, under-drains are nearly always beneficial in securing a strong foundation, and are necessary for traffic of even moderate degree. With porous soils, on the other hand, the necessity and means of drainage will depend upon the height to which the water rises in the foundation, and the direction from which it comes. When a strong foundation is needed these underdrains should be three or four feet below the surface of the sub-soil.

Their location with respect to the road should be varied with circumstances. The most effective type of drainage employed is a system in which there is a tile drain on each side of the roadway underneath the open gutters, with V-shaped drains at intervals from the centre of the roadbed to the side drains. From this the scale descends to drains at the side of the roads only; then a drain at one side only, or in the centre of the road; then only an occasional drain at springy or damp points.

It is of advantage to understand the manner in which underdrains act in different cases. With porous soils, in which the water rises under hydrostatic pressure, the water enters the tile from below. Just as water rising in a vessel finds an outlet in the sides or flows over the top, so the underdrains supply the necessary outlet for this excess moisture at a proper depth from the surface; it "lowers the water line."

With clay the process is different. Absorbing and holding as it does, like a sponge, a large quantity of water, drains are less effective, but none the less necessary. The cracks and fissures which appear throughout the surface of a baked soil during the summer drought, afford a clue to the action of underdrains upon the soil. As the clay yields up its moisture, it shrinks, is torn apart. These fissures, commencing at the drain, spread in different directions, and each fissure thus becomes a new drain leading to the tile. This process goes on, the fissures become filled with sand, vegetable and other porous matter, so that they assume a degree of permanency, and in clay soils, underdrainage is more effective after several years than at first.