the ground to the desired grade by excavation or embankment, and on this forming a foundation course more or less substantial. It should, like the foundation of any structure, be practically permanent, and constitute the main stability of the road. The surfacing is a comparatively thin wearing surface laid on the road-bed, and must be renewed from time to time. The road-bed must be kept dry, by sub-drainage if necessary, and should be given as hard and unyielding a top finish as is practicable. For city pavements, for instance, it has now long been established that 6 in. of Portland cement concrete is the best foundation for all classes of pavements. Stone block, brick, asphalt, or even wood block surfacing, all wear best on a good even layer of concrete.

In estimating grading, allowance must be made for the shrinkage, or increase, of the material from its bulk before excavation, to that after it is settled in the embankment. Shrinkage of the different materials ordinarily encountered is about as follows: —

Gravel	8 per cent
Gravel and sand	9 "
Clay and clay earths	10 "
Loam and light sandy earth	12 "
Loose vegetable soil	15 "
Puddled clay	25 "

Rock increases in bulk on being excavated, depending on the size to which it is broken, by an average of about 50 per cent., sometimes as much as 80 per cent.

An embankment or excavation will generally be stable when its transverse slope is the natural slope of the material, *i. e.*, the slope at which it remains at rest. The inclination of this slope with the horizontal is called the angle of repose of the material. However, in practice it is found preferable to use a slope somewhat under the angle of repose. The inclinations generally given, for various materials, are as follows, in the usual terms of horizontal to vertical projection:

Loose earth, loam, and gravel	$1\frac{1}{2}$ to 1
Sand	2 or $2\frac{1}{2}$ to 1
Soft greasy clay	3 to 1
Rock, sound	$0\frac{1}{4}$ to 1

Slopes of sand are best protected by sodding, but this is often difficult and impracticable.

Slight moisture in earth tends to increase its stability; but any considerable amount of moisture acts as a lubricant, and diminishes stability, until with excess of moisture the material is reduced to mud, and its stability is entirely destroyed. It is evident therefore that the frictional stability of material depends largely on the ease with which the water which it may take up can be drained away. Broken rock, shingle, gravel and clean sand allow water to pass through readily, and are the safest materials for embankment. The cleanest sand may, however, be rendered completely unstable if it is contained in a basin of material which does not allow water to drain away. It then becomes quicksand. Clay alone is better than a mixture of sand and clay. In such a mixture the sand allows entrance of water, and the clay prevents its escape.

In the drainage of roads separate provision must generally be made for sub surface and surface drainage. Sub-surface drainage has for its object the keeping dry of the road-bed, by the removal of underground water. Surfacing placed on a wet, undrained road-bed, liable to destruction by both water and frost, will always be troublesome and expensive to maintain. Surface drainage provides for the prompt removal of all water falling on the surface of the road.

Provision for proper drainage, both sub-surface and surface, is one of the most vital essentials in good road construction. No road, however well made otherwise, can endure, or give good service, if it is not thoroughly drained, but allows water, the most potent of all road destroying agents, to collect and remain on it.

Sub-surface drainage by special provision, is necessary only with certain soils. Natural soils are of the following classes: Silicious, sandy or gravelly; argillaceous, clayey: calcareous, containing lime; rock, swamps, and morasses. Silicious and calcareous soils, sandy loams and rock, are not retentive of water, and therefore require no under-drains. Argillaceous soils and marls retain water, are difficult to compact, and are very unstable under the action of water and frost. Sub-drainage of these soils in a road-bed is effected by transverse drains, or by longitudinal drains with occasional transverse outlets, to the side ditches. Transverse drains are placed, not at right angles to the road, but in form of an inverted V with the apex directed up grade. Sub-soil drains are best made of unglazed circular tile, not less than 3 inches in diameter. The joints are made by means of short sections of larger pipe, forming loosely-fitting collars. These sub-drains should be laid to a depth of 18 inches below sub-grade, *i. e.*, below the top of the road-bed, before surfacing is put on In very wet soil they should be about 15^{1} ft. apart, when not so wet 25 ft. spacing will do. They require a fall of about 1 inch in 5 ft. Their outlets from the side of the road-bed should be blind drains extending back 3 or 4 ft. These blind drains may be of field stone, laid to line.

Surface drainage is effected by having ditches, gutters, or closed drains at the sides of the road, and having the road surface of such form that the water rapidly drains off. The cross-section of the road should be kept so that there is a regular fall to the sides, uninterrupted by hollows or ruts. Side ditches should be sunk 2 or 3 feet below the surface of the road. They are given such cross-section and fall as to readily carry away all the water that comes to them. Where open ditches are objectionable, paved gutters may take their place. These should, at proper intervals, empty, through gratings, into closed drains. Or the ordinary ditch may have a strong, loose jointed, tile drain in the bottom, or a box drain made of flat stones, and be then filled up to the ground surface with loose stones. A drain of this kind in the middle of the road covered by the surfacing, also makes a good sub-drain. Ditches on inclines on which the velocity of water, after heavy rainfalls, would be greater than the nature of the soil can withstand, are improved by having weirs built across them at intervals. These weirs are of stone, in sufficient quantity, laid dry. They arrest the flow of the water, and so prevent destructive scour of the ditches. A velocity of 30 ft. a minute is not detrimental; 40 ft. per minute will move coarse sand; 60 ft. per minute will move gravel; 120 ft. per minute will move round pebbles, and 180 ft. per minute will move angular stones $1\frac{3}{4}$ inches thick.

(*Concluded in next issue.*)

COMMENTING on the bounty offered by the Ontario Government for iron ore produced in the Province, the Hamilton *Times* wisely advises people not to lose their heads over a mining craze. Such enterprises should be undertaken by experienced men; and better for them still, if they invest their own and not other people's money.