Wooden bridges supported on piles do not last for more than eight or ten years, during which period a considerable amount has to be spent for repairs. Concrete piers and abutments, if well built, should last a century or more, while the steel superstructure, with proper attention, should last at least half as long. So that, although the initial cost of a wooden bridge may be only one-half or one-third that of a steel and concrete structure, the latter will in the end be the cheapest. In addition it will be safer, less liable to collapse, and will be more convenient for traffic.

Well made concrete is cheaper and fully as durable as stone masonry. Just as the cost of stone masonry varies at different localities, in accordance with the cost of stone, labor, etc., so the cost of concrete will vary according to the relative cost of gravel, broken stone, Portland cement, and labor. For piers and abutments, the cost of concrete usually ranges from $4 to $6 per cubic yard, as compared with stone masonry at from $10 to $14 per cubic yard. Under almost any circumstances concrete is cheaper than stone masonry.

In a paper read before the Eastern Ontario Good Roads Association Mr. Allen of Nova Scotia said :

Our experience has shown us that for any span over 40 feet, iron or steel is more economical than wood, except in a few cases where the foundations are very bad and where the current and ice will permit of pile bridges being used. Nearly all of our bridges are pin connection Whipple truss, as we find these the most satisfactory, but we have used a number of riveted bridges, especially in the smaller spans.

The following table gives the current price of iron and steel for iron superstructures, made up from tenders received in 1895. Since then the prices have varied somewhat from year to year, according to the price of steel, but the tenders received this year are pretty much in accordance with this. This gives a cost per pound of about four cents, which includes the cost of erection and the cost of a wooden floor.

Iron or Steel Bridges
Current Prices

No.	Spans.	Width of Roadway: 12 feet.	14 feet.	15 feet.	16 feet.	18 feet.
1	40 feet	$ 300 00	$ 330 00	$ 350 00	$ 375 00	$ 400 00
2	50 "	400 00	430 00	460 00	475 00	525 00
3	60 "	500 00	540 00	560 00	575 00	625 00
4	80 "	900 00	975 00	1,000 00	1,025 00	1,100 00
5	100 "	1,050 00	1,175 00	1,200 00	1,225 00	1,300 00
6	120 "	1,450 00	1,500 00	1,560 00	1,600 00	1,700 00
7	140 "	2,100 00	2,200 00	2,250 00	2,300 00	2,425 00
8	160 "	2,700 00	2,825 00	2,925 00	3,000 00	3,200 00
9	180 "	3,100 00	3,275 00	3,400 00	3,525 00	3,800 00
10	200 "	4,500 00	4,800 00	5,000 00	5,135 00	5,400 00

The following is the method adopted in estimating the most economical bridge. Take a span of 100 feet with our usual roadway of 15 feet at a cost of $1,200, and supposing the iron work to last forever, provided it is properly scraped and painted, the cost per year would be as follows :

Interest on $1,200 at 4%	$ 48 00	annually
Average cost of scraping and painting...	15 00	"
Renewing wooden floors every six years..	12 50	"
Cost per year	$ 75 50	

Cost of wooden bridge for 100-foot span..	$600 00	
Interest on $600 at 4%	24 00	annually
Renewing bridge every 10 years at $600..	60 00	"
Cost per year	$ 84 00	

It would thus be seen that the advantage is in favor of the iron bridge, and we have found that this increases very rapidly as the span increases in length, whereas they become about equal when the span reaches 50 feet, and below that wood actually becomes the most economical. On the other hand, there is a great disadvantage in frequent renewals on account of the inconvenience to traffic, which, of course. is in favor of the steel bridge, but on the other hand a steel bridge is not absolutely permanent, and will have to be renewed some time, so that something should be allowed for its renewal in giving a fair comparison of both.

ROAD DRAINAGE.

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 bad conditions 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 molds 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 moist 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 ankle-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 soils, 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, underdrains 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