continuously as indicated, must represent the hitherto unknown forces AP and PB.

If the sense marks of AP and PB as found in Fig. 71 be placed on the corresponding lines of action of AP and PB in Fig. 70, it is seen that AP acts away from the point and PB against it. The member AP, therefore, exerts a tensile force and the member PB a compressive force at the point, both being forces of $4,000/\sqrt{3}$ pounds, since the triangle BAP (Fig. 71) is equilateral.

The member AP is, therefore, in tension $4,000/\sqrt{3}$ pounds, and the member PB in compression $4,000/\sqrt{3}$ pounds.

Consider the point PACDL. Acting at this point are three known forces (the load and two tensile forces exerted by the tension members PA and AC) and two unknown forces as indicated in the Statical Diagram (Fig. 72).

PA, AC, and CD (Fig. 73) represent the known forces PA, AC, and CD. From D and P, respectively, draw lines parallel to the directions of DL and LP (Fig. 72), intersecting at L. DL and LP (Fig. 73) represent, respectively, the unknown forces DL and LP, acting as indicated by the continuously pointed sense marks. In order to avoid confusion, another diagram (Fig. 74) has been constructed, showing how to arrive at the magnitudes of DL and LP. From this diagram it is seen that DL and LP are forces of $8,000/\sqrt{3}$ pounds each.

The force DL evidently acts away from the point (tensile force) and LP against the point (compressive force). The member DL is, therefore, in tension $8,000 \div \sqrt{3}$ pounds, and the member LP in compression $8,000 \div \sqrt{3}$ pounds.

Find the stress in the remaining members LG, GB, EF, and FG.

These stresses may be found by first considering the point BPLG, and then the point GLDEF.

(The correct diagrams for these points will be shown next week.)

THE ROAD SURFACE.*

By W. A. McLean, Engineer of Highways, Toronto.

Country highways of Ontario are every year increasing in importance. Without good roads, efforts to improve homes and farms, and commercial and social conditions, throughout the Province, will be largely nullified. As feeders of, and distributors from, the railways, country roads are of great importance to towns and cities. Important as country roads were before the advent of the steam railway, the extension of steam railways has greatly increased their value, for steam railways mean development; and that development, if it means anything, implies the necessity of good country roads.

The road and the vehicle are part of one machine, just as the efficiency of the steam engine is dependent upon steel rails and the roadbed. With the coming of motor vehicles a new era in the use of roads is dawning, and to reap the benefit, country roads must be equal to their new counterpart—the horseless vehicle. Ontario roads are not yet in keeping with the horse-drawn vehicle. While it may seem impracticable to aim at serving a higher class of traffic, it can only be neglected to our own loss.

Problems of road construction involve a considerable degree of skill in dealing with drainage, grades and contours, sub-soils and earthwork, road metal, road location, bridges, road machinery, etc. In addition we have systems of road management and the supervision of labour.

Treating of one department—the road surface—it is impossible to ignore various other features. Mud underneath the road is more destructive than mud on the surface, so that without a well-drained and firm sub-soil, the best road surface must prove a failure. The science of road construction is broad, and to discuss briefly a few details, it is necessary that we assume a suitable foundation, that the road is well located, that drainage is ample, and that the turnpiking is sufficient.

Road metal is placed on a road to make, so far as possible, a waterproof covering for the soil; to make a surface that will resist wear; to distribute the concentrated wheel load over a greater area of sub-soil, and to overcome the surface tendency to mud and dust.

The sub-soil should be crowned, and should be even, without depressions. This is particularly necessary in the case of clay. If there are depressions in a clay surface below the stone, water will find its way into them, will lie there, soften the soil, and weak spots will develop in the road surface through a condition of mud below it.

Before putting stone on an earth roadbed, the sub-soil should be solidified with a roller. This is too commonly evaded in an effort to keep down the cost. It is necessary that the metal form a distinct crust, if its full degree of usefulness is to be obtained. Stone forced down into a soft sub-soil is largely wasted. However firmly a surface layer of road metal may itself be rolled, it will display weakness if the sub-soil has not been consolidated. Earth in its natural state, however solid it may appear, is not as compact as rolling can make it. The cost of roads is not so much in the earthwork as in the cost of treating and hauling surface material. In the amount of metal saved from sinking into a loose sub-soil, and in the greater strength of the road, the cost of rolling the sub-soil is more than repaid.

The road metal, gravel or stone, is intended to form a separate crust over the natural soil, and should be so treated by rolling that it will be a distinct and firmly compacted covering. The benefits of rolling are numerous and difficult to sum up briefly. Rolling is an absolute necessity for the most economical, as well as most durable and satisfactory type of road. Without rolling, a large proportion of the road metal is forced into the sub-soil and wasted before it is bonded into a distinct crust. The road cannot be well formed when it is left for traffic to consolidate. The citzens who are compelled to drive through a mound of loose road metal will never give praise to the man who constructs such a road. By building a finished road on which it is a delight to drive, a little extra cost is quickly forgotten. A more durable road is obtained and the additional expense is further offset by the considerable saving of road metal.

A road surface may be constructed in various ways. The road may be surfaced wholly with crushed stone, using "crusher run"; that is, a mixture of fine and coarse, just as it comes from the crusher, without screening. This makes a surface of uneven quality and strength, and hollows and holes appear quickly under heavy traffic.

Screened stone may be used, placing the coarsest in the bottom and the finer on top. This makes a much smoother surface, of more uniform strength, than does "crusher run." It pays to screen.

Instead of making the road wholly of crushed stone, large flat stones, of sizes up to a foot or eighteen inches square may be laid on the earth sub-grade, and crushed stone spread over this. This, as a rule, is cheaper than all crushed

* Read before the Ontario Land Surveyors.