

Constant repairs at a cost of 3 cents a square yard a year will often save an expenditure of 40 cents to 75 cents a square yard for re-surfacing.

ESTIMATING COST. By Hugh A. Lumsden, B.Sc., Assistant Engineer, Ontario Office of Public Roads.

The author referred to the difficulty encountered by engineers in estimating costs of highway work, owing to the great lack of data from practical experience previous to eight or ten years ago. This data was important, despite the entry of the motor truck and its revolutionizing effect on road building.

He observed that the variety of methods and terms employed in defining unit cost produced further difficulties in that no definitely recognized unit was adopted. For instance, "a cubic yard" may be taken to mean: (1) A cubic yard of consolidated surface in finished road; (2) a cubic yard of loose stone in wagons; (3) a cubic yard on the road, not including screenings; (4) a cubic yard rolled, or (5) a cubic yard unrolled. Besides other units, *e.g.*, a ton, a toise, a cord, a square yard, etc., are also used. He corroborated Mr. H. P. Gillette's opinion in favor of the cost per cubic yard, meaning the cost per cubic yard of material of consolidated road after its construction is completed.

Familiarity with local conditions is essential before commencing an estimate; with the traffic the road may be expected to carry; with the character of the soil; with the present condition of the road; with the extent to which hill cutting and grading will be required; what diversions may be advisable; what local material may be obtained, or freight rates to nearest siding; the quality of local material; what road machinery is available; cost of local labor, men and teams, and many other items which occur, peculiar to each individual road.

On commencing to get out an estimate on a road of any kind, states Mr. Lumsden, we would urge the necessity and the aid provided in having before one a map showing the location of road to be built, and a cross-section showing the type of road it is proposed to construct. The presence of such drawings may often remind one of special features in connection with the work which might easily otherwise have been overlooked.

Where different local conditions will be met with, it is wise to divide the whole road into a number of sections, over each of which conditions will be approximately the same, and for each work out an estimate. Thus we may have a section to stone along which it is more economical to ship in stone and haul to the road, while on an adjoining road or section it may be cheaper to use local stone from nearby quarries.

Mr. Lumsden then follows, in the manner given below, the construction of a waterbound macadam road, selecting that type for its great mileage and the many features common to all roads that it comprises.

After determining the diversions required, the cost of right-of-way per acre is figured next. On these diversions some clearing of right-of-way and grubbing may be necessary and the cost of clearing and grubbing per acre is thus required. Permanent structures must be provided for. For bridges, by which we mean structures of 10-foot span or greater, it will usually be found not only safer but more economical in the end to employ a bridge engineer. For culverts, the cost of similar structures built in the neighborhood will serve as a fair criterion by which to check up our estimate. The cost of culverts (shown as so many cubic yards concrete and so much per yard) the number of pipe required, their proposed location,

length and diameter, must then be summarized, as thus 400 feet C.I.P. @ 75c. per foot. We must first know our purchase price of pipe f.o.b. at nearest siding and also what it will cost to haul that pipe onto the work, and estimate so much per foot for the laying cost.

Having then completed the estimate of expenditure for bridges, culverts and pipe, we should consider that of grading. This item will necessarily vary greatly, depending on the particular sort of country through which the road runs. Rather than take the cost on similar roads and for estimating, and state a certain lump sum per mile, it is very much preferable in every case to run levels over the road, plot a profile, lay down a grade line and work out the approximate yardage to be moved, where possible, making cuts and fills balance. The slight expense necessary to lay out the work in this way is saved many times over in future years by reason of the increased efficiency of the road.

Having found the quantities to be moved, we must decide on the most economical means of moving. A small No. 2 drag scraper or slip weighs about 100 pounds and holds approximately $\frac{1}{8}$ yd. Where the grade is being built from side borrow, circular runways leading up onto the grade are used, around which three or four teams are continually working, one extra man to load the scrapers being required. The average man and team will probably put in from 60 to 80 yards of average material. Where a haul of over two hundred feet is required it is more economical to use wheelers, the smaller sized wheelers being used for heavy, tough soils and those of larger size in light soils. No. 1 wheeler will hold $\frac{1}{5}$ yd. and No. 2, $\frac{1}{4}$ yd., No. 2½, $\frac{1}{3}$ yd., and No. 3, $\frac{4}{10}$ yd. In hauling by wagons 4 men should load a yard wagon in 4 or 5 minutes. A good average team can be expected to haul a load from 10 to 15 miles and return empty in one day. In estimating what we may expect a wagon to haul to the load, much will depend on the state of the road. Gillette estimates that on very poor roads of heavy sand or gumbo less than a yard of material could be safely loaded; for ordinary poor earth roads one yard, and for good earth roads a yard and a half can safely be hauled, while over good macadam roads $2\frac{1}{2}$ yards is not too big a load. To loosen up material a team on a plough may be expected to loosen from 300 to 500 yards per day.

The cost of the stone, concrete, or whatever material is to be used in the subgrade is, as a rule, by far the greatest item in cost of construction. Under this head we often estimate the cost under the four headings: (a) Materials, (b) Labor, (c) General expenses, (d) Supplies.

In following out a waterbound macadam road we may thus enumerate the principal items which must enter into any estimate of cost:

1. Cost of Materials.—Where broken stone (to arrive at the actual cost of crushed stone of required size at the quarry in cubic yards) is obtainable locally the portable crushing and screening plant required may be expected to cost in the neighborhood of \$3,000. This will include crusher, screen and bin, 15 h.p. engine and boiler. To operate such a plant requires an engine man, foreman and two men to feed the crusher. One hundred yards per day would be a fair output for such a plant, and the average actual cost of crushing and screening may be expected to run from 25c. to 35c. per yard.

The only factor in regard to screenings is that, although screenings will be required over and above what will be got from the crusher, when crushing the required amount of rock, there is usually such an abundance about the quarries that a somewhat lower charge will often be