

made for screenings. From 40 to 70 cents per yard is very often the purchase price of crushed rock.

The charge for freight on stone and screenings varies somewhat, due to switching charges where the road is located on a line other than that on which the quarry is situated; where shipment can be made direct over one line the freight rate, within a radius of 65 miles, is 60c. per ton-mile. When switching is required another 60c. is usually charged. Competition on the part of the railways may often change these rates which, therefore, depend largely on the location of the quarry.

It is unusual that any charge will be made for the use of water. Where this is done it varies greatly. The possible cost of pipes to furnish water of pumps, etc., should always be taken into account. The amount of water we should expect to use will depend largely on the quality of the stone and on the weather. From 2 to 3 gallons per square yard is a fair approximation.

2. Labor.—For loading stone and screenings a fair average would be $2\frac{1}{2}$ c. per cubic yard, when loading from screening bins. From cars, 1 man can load from 15 to 20 yards per day.

In hauling stone and screenings a very common size of wagon box is 9 ft. long by 3 ft. wide by $1\frac{1}{2}$ ft. high, containing $1\frac{1}{2}$ yards. Since loose broken stone consolidates about 10% when hauled even a short distance, it is important to state whether the measurements to be made after loading the wagon or when the stone is delivered at the work. From 22c. to 25c. per cubic yard per mile is a fair average for hauling with wagons.

This cost of hauling is one of the greatest items, as well as one of the most interesting. In this connection the writer was fortunate enough to hear a most interesting paper by Professor Agg, of Iowa State College, read at the American Road Builders' Congress at Chicago two months ago. He enumerated the chief factors entering into the cost as: (1) Length of haul; (2) rate of travel; (3) time lost while loading at cars and unloading at work; (4) time lost in travel on account of bad roads; (5) capacity of outfit per trip; (6) cost of operation. In estimating, he assumes speeds of $2\frac{1}{2}$ miles per hour for teams, 3 miles per hour for traction outfits and 10 miles per hour for motor trucks. Average hauling capacity he assumes as: Teams, 2 tons; motor trucks, 5 tons; traction outfits, 15 tons, and he valued teams at 50c. per hour, motor trucks \$2, and traction outfits \$3.

In spreading stone binder one man should spread 30 to 40 yards in a day; nevertheless, a mechanical spreader would probably reduce the cost.

In rolling about 65 yards of loose stone will compact to 50 yards compacted material. A cost of 25c. per cubic yard of compacted material is reasonable. A roller should roll from 60 to 100 cubic yards per day.

For a foreman a wage of about \$4 per day is a fair average. This amounts to 5 cents per cubic yard of material.

3. General Expenses.—Under this head we would include the salary of superintendent, watchman and water-boy, timekeeper, insurance on working, etc. All of these would amount to about 20c. per cubic yard of material.

Supplies.—This includes cost of coal, of oil and of waste, all for the roller; also interest, depreciation and repairs on roller, wagons and other road machinery.

The question of depreciation in the value of road machinery may be of interest.

Records show that there is no reason whatever why rollers (the original cost of which runs from \$2,500 to

\$3,000) should not last from 20 to 25 years. Several rollers on which careful records have been kept have been known to last this length of time in England, although wheels and other parts may have been replaced.

Engineering.—The great importance of this item in connection with roadwork, as in all other kinds of work, cannot be too greatly emphasized. Even if engineering costs may run as high as 5% to 10% of the total cost of the work, be assured that this cost is made up many times over in the money that will be saved in each and every feature in the work, through employing capable engineers to draw up plans and to superintend any construction work in progress.

Contingencies.—Notwithstanding the greatest possible care and forethought, this item should always be provided for. Fifteen to twenty per cent is, we believe, a reasonable allowance.

Having totalled our cost of construction and shown what it will cost per cubic yard of material in place we should then refer to previous data showing cost of construction of similarly built roads, and if greatly different we should then go into details to discover the cause of the difference. In this way are published data and records of the very greatest assistance.

One is frequently asked the cost of putting on a surface coat of tar or heavy oil; for instance, Tarvia. A fair average for estimating purposes would be 10c. to 12c. per square yard for first application, including stone chips, the amount of Tarvia applied being from $\frac{1}{3}$ to $\frac{1}{2}$ gallon per square yard, costing from 10c. to 15c. per gallon.

An enquiry made some years ago by the Washington Office of Public Roads showed that the average cost of gravel road in 31 States of the Union was \$2,047 per mile.

For macadam roads in 34 states the average cost was \$4,989 per mile.

COST KEEPING AND ACCOUNTING. By W. Huber, A.M.Can.Soc.C.E., Assistant Engineer, Ontario Office of Public Roads.

In emphasizing the value to road engineers and superintendents of the keeping of records, the practice of contractors in this respect is referred to as being one of the greatest assets to his success in estimating on new work and in keeping each phase within or close to the estimate during progress of construction. The latter's cost records of grading, excavating, haulage, materials, etc., enable him to figure closely, reducing the amount to be added under the head of contingencies. It is observed that by giving such work the same attention as the contractor would give it, and by insisting on the same degree of efficiency from employees, the road superintendent or engineer should be in a position to do his work as cheaply and as efficiently as the former.

The success and economy of road construction is pointed out to be a matter of efficiency—in handling machinery, directing labor and selecting materials. An efficient system of cost keeping has for its objects:—

(1) To enable the superintendent to prepare at any time, either on completion or during progress, a detailed statement of the cost of each section of road built, showing the expenditure on each part of the work as, grading, culverts, cost of stone, labor, etc.

(2) To show, while work is in progress, the unit costs of various operations, as cost of quarrying or crushing per cubic yard, cost of excavation per cubic yard, cost of draining per rod, cost of hauling stone per yard-mile, cost of finished road per square yard or per mile, etc.