

per hour should not be undertaken down a grade of more than 3% with a vehicle bearing any kind of a load. In ascending a 5% grade the capacity of the team is about $\frac{4}{10}$ of its capacity on level ground and about $\frac{1}{4}$ of its capacity on 10% grade, on a loading for the same tractive exertion, but a point here that should not be forgotten is that for a short duration a horse can exert from 25 to 40% of his weight, thus doubling and quadrupling its normal tractive force and in this connection it is often better economy, considering the financial condition of the community, to put in a short piece of 6 and even 7% grade, than to expend a large amount of money in making an exhaustive and expensive cut, especially so if the cut must be made at the expense of development in some other part of the community. One thing that should be borne in mind is that each year's development of our country makes the chances for changing of grades and their elimination less possible, and that while the improvement of the surface of a road increases its tractive efficiency about 200% on level ground it only increases about $\frac{1}{4}$ for a horse-drawn vehicle on a 10% grade, thus money expended in decreasing the grade within a reasonable amount of distance is the best possible investment.

Then, with these conclusions drawn and a decision as to the kind of surface that will possibly be placed upon the road at some future time, we are in position to determine what should be the maximum grade.

Methods and Costs of Grading and Excavating.—

This is a machine age and wherever grading can be done by machinery it is usually more economical. The following table, based upon figures taken from different pieces of work, is approximately correct to a wage scale of 15 cents per hour and capable supervision.

By a glance at the figures it will be seen that at 22 cents per yd., or at the same cost for any given ratio, the ratio cost distances are: for wheelbarrow, 200 ft.; drag scraper, 400 ft.; wheel scrapers, 500 and 600 ft.; 1-horse cart, 1,500 ft.; wagon, 1,800 ft., while tractor and truck on track do not reach the amount within one mile. The cost of grading depends materially upon the class of material, the location and the management of the operation.

As to methods, the writer would suggest the use of machinery wherever possible under competent supervision and under proper direction. On work that is light and on which machinery can be employed the work should be done by day labor. On heavier work and large quantities the writer would recommend contracting, and to the contractor a systematic organization of his work so as to get the most efficient service from his men and equipment. There are volumes written covering the subject of cost data in heavier work, but my experience in highway work leads to the conclusion that there are many elements entering into the cost of highway construction that are often overlooked when comparing this class of work with heavier work. One point of deficiency that has been noticeable and should be emphasized here is the lack of organization in highway construction in the various sections of the country. In many instances 50% of the cost could be saved by an adequate organization.

Economical Considerations.—The economical phases of highways and highway construction are many, and call for more than the available space. The history of highways and highway economics can be divided into three periods: The Roman or Ancient Road; the Telford and Macadam period, extending from 1750 to about 1840, and our modern or twentieth century awakening. The Roman road, with its 3 feet of stone, was reduced about one-half in the days of Telford and Macadam, and now, with modern machinery, we are constructing macadamized

roads at costs ranging from \$1,000 to \$4,000 per mile, concrete from \$7,500 to \$12,000 per mile, and brick from \$9,000 to \$20,000 per mile. It should be borne in mind that the cross-section of a road should be so as to permit the greater portion of the work to be done by machinery on ground where machinery can be operated, and that an extra width of the road on hillsides increases the cost. A road on hillsides should not be wider than is needed to care for the traffic. In country districts a 9-ft. concrete bituminous or brick or a 10-ft. macadam with 5 ft. of earth on each berm will meet all the requirements at much less cost.

On ground free from roots and stone, where a road machine can be used the material can be moved at a cost of less than 5 cents per yard, and on hillside grading, where the work is casting, a small steam shovel is an economical machine to use. With this should go a drilling outfit and attachments so it can be operated with the same power.

In conclusion, the most economical thing a community can do is to improve its roads so as to serve all its demands, and to do this it should employ a competent highway engineer to make a careful study of the needs of the territory, its financial ability to construct and maintain a road and to locate and superintend the construction of their road for them. When the road is constructed a competent patrolman should be placed on it to continually keep up the maintenance and repairs.

DOMINION GOVERNMENT ELEVATOR FOR VANCOUVER.

The Department of Public Works, Ottawa, purposes constructing a grain elevator with a capacity of 1,500,000 bushels on the government dock on Burrard Inlet, Vancouver. A site 578 x 352 feet with an additional wharfage 800 x 300 feet is being prepared.

The foundations of the plant are to be concrete piers carried down to concrete footings which shall rest on natural bedrock.

The buildings will be of reinforced concrete and will consist of a working house, track shed, storage house, sacking plant, transformer building, and conveyer galleries to handle bulk grain and grain in sacks from the elevator to the dock.

The whole of the work is to be furnished complete and ready for operation to receive, clean, and ship bulk and sacked grain on or before November 1, 1915.

The elevator will complete the chain of terminal and interior elevators erected by the government throughout the west from Port Arthur to the Pacific. The Vancouver elevator is intended to take care of the grain which will move westward from the prairie provinces for shipment via the Panama Canal.

Tenders close on November 30th.

In view of the fact that the war had cut off the supply of blocks formerly secured by England from Northern Europe, British Columbia millmen have forwarded to London samples of blocks made from British Columbia fir.

Division engineers of the New York State Highway Department have been directed in submitting estimates for construction to include hereafter an approximation of the number of working days required to complete each contract. This, it is expected, will enable the Highway Department to specify time limits on contracts more accurately, as the local engineers who work up the field notes are unquestionably in a better position to weigh carefully the elements which enter into the building of a piece of road than the office force are.