ECONOMICS OF ROAD CONSTRUCTION

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ECONOMICS OF ROAD CONSTRUCTION.

Chapter I.

HISTORICAL REVIEW.

The roads of the Romans were built at enormous cost, probably not less than $50,000 a mile. They were constructed of stone laid in mortar, the courses aggregating about 36 ins. in thickness. No regard was paid to topography. Hills were climbed or excavated, even where by a slight deflection they could have been avoided, and drainage ditches seem to have been entirely omitted. It was not until 1764 that Tresaguet, a French engineer, began to construct roads upon scientific principles by using small broken stone placed upon a well-shaped bed of larger fragments set on edge. The same type of road was later introduced into England by Telford about 1824, and roads so constructed are generally known by his name.

About the same time, or possibly a little earlier, a genius appeared in the person of Macadam, who discovered that the foundation course of large stone set on edge was unnecessary; and that, provided the soil was well drained, a bed of loose broken stone some 6 to 12 ins. in thickness would become sufficiently bound together under traffic to uphold the heaviest of wagon loads. No further advance in the science of road construction occurred until the invention of the stone-crusher and the introduction of the steam road roller, both within recent years.

It may be safely said that half the controversies between engineers over the subject of road construction are due to the fact that one class of engineers still adheres to the rules of Macadam without recognizing the changes wrought by the steam roller and the crusher. The broken stone road of to-day is quite a different structure from the type of road built by Macadam, who used hand broken stone that was practically uniform in size, laid in the road without the addition of a binder of stone dust or sand and left to be compacted by passing wheels. What was the result? The wheels cut ruts in the loose stone until the soil worked up from below, while the action of the wheels powdered and broke some of

the stone until the voids were filled, and the mass became packed, weighing 90% to 95% as much as solid stone. In this process it took 18 ins. of loose broken stone to make 12 ins. of macadam surface, or 1.5 cu. yds. of loose stone to 1 cu. yd. of macadam. To this day it is therefore stated in every text-book known to the writer, that the steam roller will compress loose stone one-third, or that 6 ins. will roll to 4 ins.; which is one of the errors that seems never to be contradicted.

Rolled as roads now are with a steam roller, no such compression as this is possible; although in cases where the stone is placed upon loose unrolled earth sub-grade some stone is driven into the earth and lost, which has led many engineers to believe that the roller had compressed the stone 33%, or even more. This is mentioned as but one of the errors commonly accepted as truth, and one that is in a measure accountable for too high estimates of the amount of broken stone required on the one hand, and too low an estimate of screenings on the other hand. The true shrinkage will be given later.

With the introduction of the rock crusher came a large amount of stone dust or screenings (½-in. diameter and less). These were at first rejected as being worthless, in fact detrimental to good road construction, but some one with more brains than book-learning tried them, and found that they made the road bind more quickly and gave better results than were attained by following Macadam's specifications. The use of a binder in conjunction with the steam roller then made it possible to build a good road in a few days, where formerly it had taken months; and it led to the building of "thin roads," of 6 ins. and even 4 ins. depth of road metal. Such a radical departure from precedent was and still is ridiculed by some engineers, but common sense and economy seem now to be winning the day.

We have seen the thickness of broken stone roads reduced from the 36 ins. of the Romans to the 18 ins. of Telford, to the 12 and even the 6 ins. of Macadam, to the 6 and in some cases the 4 ins. of to-day.

The recent achievements in economic road construction are due entirely to three factors: (1) Proper drainage and rolling of the earth foundation; (2) The use of machine broken and screened stone with the screenings for a binder; (3) Thorough consolidation with a steam roller; and it is safe to say that an economic road cannot be built unless all of these factors enter into its construction. There is yet another factor that up to the present has

been ignored by engineers; namely, the use of machines for grading. Contractors have been, and are, well aware of the great economy attending the use of drag and wheel scrapers, of "road machines" and Shuart graders; but the cross-section of roads designed by engineers is usually such that the use of these machines is practically impossible. A reference to the reports of the Massachusetts Highway Commission will disclose the fact that about 5,000 to 6,000 cu. yds. of earth excavation are made per mile of road, at an average cost of about 33 cts. per cu. yd.; wages being $1.50 for labor and $4.00 for team and driver for nine hours.

It can be positively stated that both the amount of excavation and its cost can be greatly reduced, and probably 50% saved, simply by a change in the cross-section of the road, permitting the use of scrapers, and by a change in specifications, permitting some vegetable matter in the embankment, and the requirement of less labor in slicking, or "sandpapering," the slopes of embankments, and omission of sprinkling and rolling during construction.

This statement will become more clear upon perusal of the next chapter.

Chapter II.

EARTH ROADS AND EARTHWORK.

The cheapest in first cost and consequently the most common form of road is one made entirely of earth, properly crowned and rolled, either by wheels, or by rollers; and in any case, whatever may be the paving material, the cross-section should be designed along the lines now to be described, if true economy in construction is desired.

PROFILE OF CROSS-SECTION OF ROAD.—It is too prevalent a practice to design a uniform cross-section for a road, regardless of the soil of which it is made; regardless of the climatic conditions, and the drainage area that the ditches must serve; regardless of the inclination or slope of ditches, and regardless of side-hill or other excavation. As an introduction to the consideration of these factors present practice in road construction will be discussed, as exemplified by the standard cross-section used and recommended by the Massachusetts Highway Commission.