THE CEMENT CONCRETE ROAD*

By W. P. Near
City Engineer, St. Catharines, Ont.

PERHAPS in no other type of road construction has there been such marked improvement in methods of construction and in standardizing of specifications as has been accomplished with the cement concrete road during the last ten years. It had been advertised that mixing and placing of concrete was the work of an unskilled workman, but the experiments of these years have proven that the intelligence of skilled workmen and trained foremen and engineers are needed, and pays for itself in results attained. During this ten-year period concrete roads have grown in popularity, as shown by the fact that in 1909 they had been laid in only one province (Ontario), and to the extent of 72,000 sq. yds., while at the end of the year 1919, concrete roads had been constructed in every province in Canada to the total of 3,970,459 sq. yds. In the United States, during the year 1919, there were constructed 53,459,934 sq. yds., making a total yardage at the end of 1919 of 167,015,086 sq. yds. In the presence of these figures, it is not my intention to use this paper to describe concrete roads or methods of construction, as they have been standardized, and are, no doubt, familiar to all of you. But with all of our experience, there always remain some features of specifications and construction methods which require to be kept constantly before us if we are to secure best results. I will attempt to bring a few of these features before you, and in doing so lay no claim to any originality for the suggestions made.

Preparation of Sub-Grade

It has been usual to bring the sub-grade to proper contour, leaving it a little high to allow for rolling, and then to consolidate by rolling and re-rolling with a heavy steam roller, filling up the depressions and re-rolling until the entire sub-grade is consolidated.

Now, many engineers contend that the sub-grade should receive little or no rolling. Particularly is this true for heavy clay and gumbo soils. They recommend that the sub-grade should be brought to within one or two inches of the desired elevation, the side forms should then be accurately set and the remaining portions of the sub-grade carefully scraped or honed to desired contour. On clay and gumbo soils, which shrink and swell excessively with variations between dry and moist conditions, it is recommended that a layer, three or four inches in thickness, of cinders or fine gravel, be placed upon the sub-grade before the concrete is laid.

Where the usual methods of ploughing and rolling are adopted for preparation of sub-grade, it is recommended that the ploughing should extend ten or twelve inches below sub-grade. The surplus material then is excavated and removed and the sub-grade consolidated. This will produce a sub-grade of a more uniform bearing capacity than that secured by attempting to plough only as deep as the finished sub-grade. It is also claimed for this method that it is economical from the contractor's point of view, in that the materials are more easily excavated resulting from the deep ploughing.

Care of Sub-Grade before Placing of Concrete

So often it happens that the sub-grade is prepared in a perfectly satisfactory manner, and while materials for the concrete are being hauled and distributed, a few wet days will cause the sub-grade for long stretches to be rutted and cut up and previous preparation destroyed. Then the sand and stone become mixed with the grade; much of it is lost and the quality of the remainder very much lowered. The remedy for this is in the central mixing plant and the industrial railroad; and such good results to the concrete can be secured, as well as economies in the handling of materials, that I think the day is coming when specifications will require that when the sub-grade is once prepared that all driving and traffic over such sub-grade shall be prohibited until the concrete is placed.

The idea of a central mixing plant is not necessarily confined to a large contractor's plant. Small units, with half-mile to a mile of track, necessitating the moving of the central plant as each half-mile or mile, as the case may be, of road is completed, should be quite feasible, and, with proper organization, should prove economical. After each shift of the central plant the sub-grade may be given its final preparation, with no further fear of disturbance until the concrete is placed.

Consistency

One of the commonest of bad practices amongst concrete construction plants, especially of small or moderate sizes, is that of using too much water in the batch. Larger construction units, with mechanical tamping and finishing devices, are not so prone to make this mistake. It used to be assumed that enough water to make the cement set was necessary to make concrete, and more did not hurt any. The men handling the mixed concrete, especially from a mixer employing a chute, encourage the use of excess water, because it makes handling easier for them, and the operators of the template, or strike board, are usually fond of a sloppy mix. In this regard, the investigations of Prof. D. A. Abrams, of the Structural Materials Research Laboratory, Lewis Institute, Chicago, have shown conclusively that the strength of concrete depends absolutely upon the ratio of the amount of water to the amount of cement, and that the use of more water than is necessary to produce a workable consistency is not only wasting cement, but is producing a concrete from one-third to one-half the normal strength. It is also established that compressive strength of concrete is a direct measure of its wearing quality, so that the possibility of reducing the wearing qualities of a road by too liberal a supply of water in the mixing may assume tremendous proportions.

Slump Test

A test for consistency which may readily be made on the work has been devised by the Illinois State Highway Department, and is known as the slump test, using a truncated cone. The method of making the test consists in filling a thin metal mould in the form of a truncated cone, having an 8-in base, 4-in. top and 12 in. high, with the freshly-mixed concrete, which is lightly tamped by a rod as the concrete is placed in the mould. As soon as the mould is filled and struck with a trowel it is removed by means of handles, and the height of the concrete after removal of the mould is measured. The difference between this height and the height of the mould is taken as the measure of the slump. For concrete pavement the slump for a workable consistency lies between ½ in. and 1½ in., depending, respectively, on whether mechanical tamping and finishing is used, or whether the template is worked by hand. When the proper consistency of the batch has been determined by this means, the appearance of the concrete is noted and used as a guide for future batches, with only occasional slump tests being necessary. When it is proven that 10 to 15% excess water has cut down the strength of the concrete nearly 50%, it must be realized that too much importance cannot be attached to the question of consistency.

Specification for Consistency

The amount of water to be used for mixing concrete shall be that which will give a consistency to be determined as follows:—

Newly-mixed concrete shall be placed in a metal mould of the form of a truncated cone having an 8-in. base, 4-in. top and 12 in. high. The concrete shall be lightly tamped with a rod as it is placed in the mould, which, when filled, is to be immediately removed by means of handles on either side of the mould, and the slump or settlement of the concrete noted. For concrete to be finished by a mechanical tamping machine, the slump shall not be less than ½ in. nor exceed 1 in. If the concrete is to be finished by hand methods, the slump may be as much as 1½ in.

Our specifications for proportions are fairly fixed at 1: 2: 3, or thereabouts, and the grading of the fine aggregate

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