Designing Flexible Pavements (Virginia)

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THE design of flexible pavements in Virginia is based on the California bearing-ratio method (C. B. R.) with certain modifications. Since everyone interested in the subject is more or less familiar with this method, only the modifications will be elaborated on in this paper.

First it was decided that since the state specifications required that all fills and subgrades be compacted to 95 percent of theoretical density as determined by AASHO Method T-99, that it would be better to test the specimens at this density rather than at the density specified in the procedure as originally developed, as this would more nearly meet field conditions. Realizing that it would be impossible to obtain these densities with the procedure as set forth in the recognized method, it was decided that the test specimens be compacted using the 5½-lb. compaction rammer. The next thing that had to be determined was the number of blows necessary with this rammer to obtain the right density using the larger C. B. R. mold. After many tests with different soils, it was found that proper results could be obtained by using 45 blows and compacting the soil in five layers. The original test as developed required that clay soils be soaked until there was no further swell or expansion. Since several agencies had decided on a 4-day soaking period for all samples, it was decided that we would standardize on this time. All samples are now soaked for this period of time. Of these modifications the density at which the specimens are compacted seems to have the greatest bearing on the resultant design. This density naturally gives a lower C. B. R. value, which necessitates a greater thickness of treatment. It is felt, however, that since the specified density of the subgrade is the same as that at which the specimens are tested, the design depth is nearer to what it should be to carry the load than if the higher density was used.

Along with the values obtained from the modified test procedure, the anticipated traffic and loads are also used in the design depth of the pavement. A set of curves, as shown in Figure 1, based on those that were developed by the Corps of Engineers is used to determine the depth of pavement necessary for the various loadings. You will note also on Figure 1 that a minimum depth of pavement is required for given loads.

To explain the mechanics of the method, I believe a description of a project where this method was utilized would more clearly define the procedure.

As soon as the location survey was finished, the proposed alignment and grades were furnished to the soils laboratory, so the soil survey could begin. At this time a request was also made for a traffic study, so the anticipated traffic and loads could be determined. This information was also to be used in the final design. The soil survey was made with a mechanical soil auger capable of making borings up to 100 feet in depth. This enabled the survey crew which usually consists of an operator, two soil technicians, and two to three laborers to thoroughly explore the deepest cuts throughout the project. Usually the borings are made to 3 feet below the proposed grade. Samples were obtained for all types of soils encountered in both fill and cut sections. A complete log was kept of the changes in soil encountered throughout the project and recorded on profile plan sheets. Samples were also taken of the various layers of soils. After all of the test information had been obtained, this information was useful in selecting the better soils to be used for capping purposes during the construction of the project.

On this particular project which was on an old location and where little change in grades and alignment were contemplated seven samples were actually tested. The C. B. R. soaked values ranged from 3. 2 to 30. 0. Two of these samples were of the existing soil base and naturally had the higher bearing value. Careful consideration was given to all of the characteristics of the soil samples along with the C. B. R. values in order to determine which were the better soils to use in the upper layers.

There was one long section on the project where the soil was found that had the C. B. R. value of 3. 2. It lay directly beneath 'the existing base. The existing depth of base was not nearly enough to carry the anticipated traffic even if the new pavement was placed on top. After a thorough study it was found that by placing a 10-inch layer of subbase material,

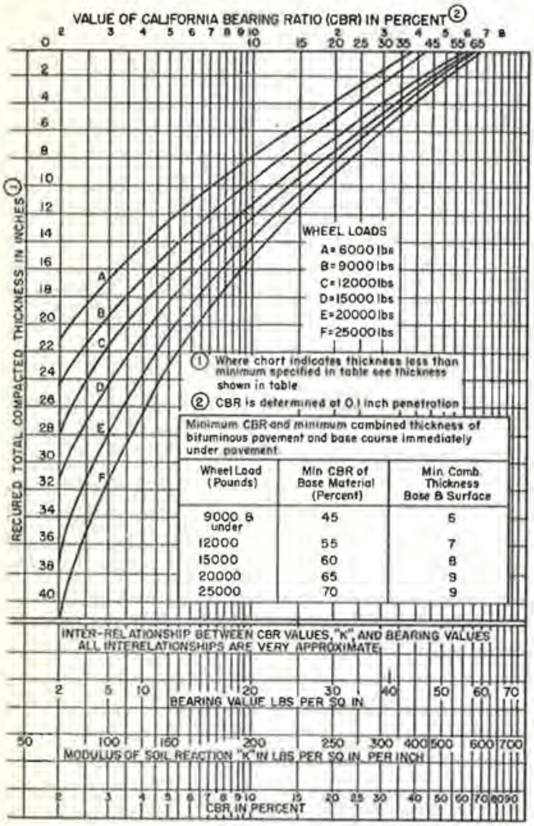

Figure 1. Design curves used for pavement depths required for various wheel loadings.

which was available on the project, on top of the existing base and then placing the new pavement on top of this layer, sufficient depth would be obtained. This subbase material was required to have specified C. B. R. value when tested in accordance with Virginia's method. In doing this the proposed grade was raised an extra 10 inches, which was highly beneficial through the section. Further studies indicated that, by utilizing the existing base material (which was a local sand-gravel mixture) as subbase for the new pavement, the design depth could be satisfied for the other sections where the soils were found with the better C. B. R. values.

The original idea for the design of the pavement was to use a standard depth throughout the entire project. After the C. B. R. studies were made this was all changed. The section of the project with low C. B. R. values was designed to use 20 inches of subbase with an 8-inch asphaltic concrete pavement. In the sections with the better C. B. R. values, the asphaltic pavement was the same; however, the subbase depth was cut to 8 inches. During the construction of the project, close control was maintained to check every change in the material to see that the select subbase material met all requirements and that proper drainage was obtained. Close checks were also made to see that all the materials were well compacted to specified densities prior to the construction of the pavement. The pavement consisted of three types of mixes as follows: $5\frac{1}{2}$ inches of base using the natural pit material with 4 percent asphalt, $1\frac{1}{2}$ inches of binder course with controlled gradation requirements and with 5. 5 percent asphalt and a 1-inch top course of sand asphalt with 7 percent asphalt. The overall depth of pavement was 8 inches. These mixes were also closely checked to insure that the proper stability was being obtained.

It has been agreed that if the original design had been followed the section with the lower subgrade values would not have been strong enough and wholesale failures would have resulted. This project is approximately 3 years old and to date not one failure has occurred. The road is carrying an exceptional amount of heavy truck traffic along with a high count of basic vehicles. Even though the subbase was increased in the poorer sections the overall cost was materially reduced over that which was originally estimated. Certainly the maintenance has been reduced.

After the design of several projects, the question arose as to how much the cost of construction would be increased if this method of design was used. In many instances the initial cost seemed to be greater, but on further investigation it was found that by utilizing the better materials to cap the inferior ones a considerable saving could be made. In following this procedure, the depth of high-type pavement required was materially reduced. This reduction usually more than offset the cost of selective grading. Naturally this is not always the case, especially in areas where the poor soils abound, but it must be granted that if the road is improperly designed excessive maintenance costs would be the result. To date on all the projects that have been designed according to Virginia's method the maintenance has been very low.

Since the method has been employed in Virginia over 75 projects have been designed over all types of soils. The total depth of treatment has ranged up to 48 inches. There have been many cases where the inferior soils have been capped with as much as 36 inches of better material. These better soils were found on the project, or were available close to the work from select borrow sources. The pavement depths have ranged from a minimum of 7 inches to a maximum of 16 inches and have been constructed with all types of base materials and surface course mixtures. In studying the costs involved it is believed that there has been no material increase in overall cost. The plans provided are so detailed that the contractors know exactly what is expected and the works progress very smoothly.

This method of design has been used for all types of construction including reconditioning of all pavements, new locations, and ones where both minor and major changes are made in grades and alignment. On many of the reconditioning projects it has been found that many sections of the old road have to be completely reconstructed, while in other sections only a new surface will have to be applied. On new locations, in many cases, it is necessary to place better materials to depths as great as 24 inches before placing the subbase and pavement. In other instances, where certain grades have to be maintained, it has been necessary to excavate to depths as great as 48 inches and backfill with select material of a known C. B. R. value before constructing the pavement. The idea behind the design method is to provide a uniform subgrade on which to place a uniform depth of pavement that will support anticipated loads with a minimum amount of deflection in the pavement.

Projects that have been designed and constructed to date are very young; however, the results indicate that they are doing the job in a most satisfactory manner. So much so that recent instructions have been to design all projects on Class I and II roads by this method with the hopes that just as soon as personnel and equipment are available that all projects can be designed accordingly. It is realized that this method is not the ultimate but until a more rational one is developed it will be continued in Virginia, since it has proven that it is much better than using the old method based on experience.