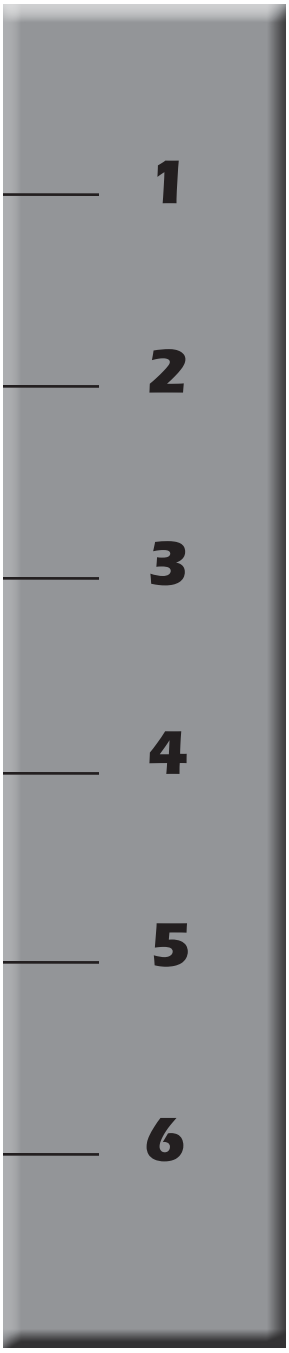


Inch for Inch...

By Randell C. Riley, P.E.

In the competitive climate in which pavement type selection decisions are made, many factors are considered. The concrete industry has always claimed the life-cycle cost advantage. We had to. We cost too much up front due to the safety factors imposed in concrete pavement design compared to asphalt pavement design. However, in the parking lot market rarely do specifiers, architects and, frankly, engineers really care about life-cycle costs. It is all about that first dollar spent.

Recent changes in the economics of concrete pavement relative to asphalt have led many to believe we are suddenly more first cost competitive, but let me show you that concrete has always been first cost competitive if you were designing the sections to actually carry roughly the same traffic and get the same life.

Let's take a typical Illinois parking lot pavement section. How many of you have routinely seen a section of 3-inches of bituminous surface on 6-inches of granular material? How many of you have seen even less? How many inches of concrete would it take compared to what the engineers and architects frequently pull out of their mysterious design manual? And why? Let's start with the why.

Most engineers and architects start one of two places in Illinois: either Chapter 54 of Illinois Department of Transportation's (IDOT) *Bureau of Design and Environment Manual (BDE Manual)* for highways or Chapter 37 of IDOT's *Bureau of Local Roads Manual (BLR Manual)*. Are these really appropriate for parking lots? Probably not! IDOT designs for controlling vehicles that are principally trucks – and usually a lot more than we are inclined to see on a typical parking lot.

For example, both of these resources start at bottom traffic levels with about 12 percent truck traffic. If you know what you are doing there are provisions to go below this level, but even then the minimum thickness for concrete from the design charts is about 7.5 inches in the *BDE Manual* and 6.5 inches in the *BLR Manual* for soil conditions typical of parking lot construction. Both procedures are mechanistically based and incorporate extremely high levels of reliability. Both also imply that granular subbase is optional at traffic levels typical of parking lots, but explain optional to most engineers and the word required seems to take its place.

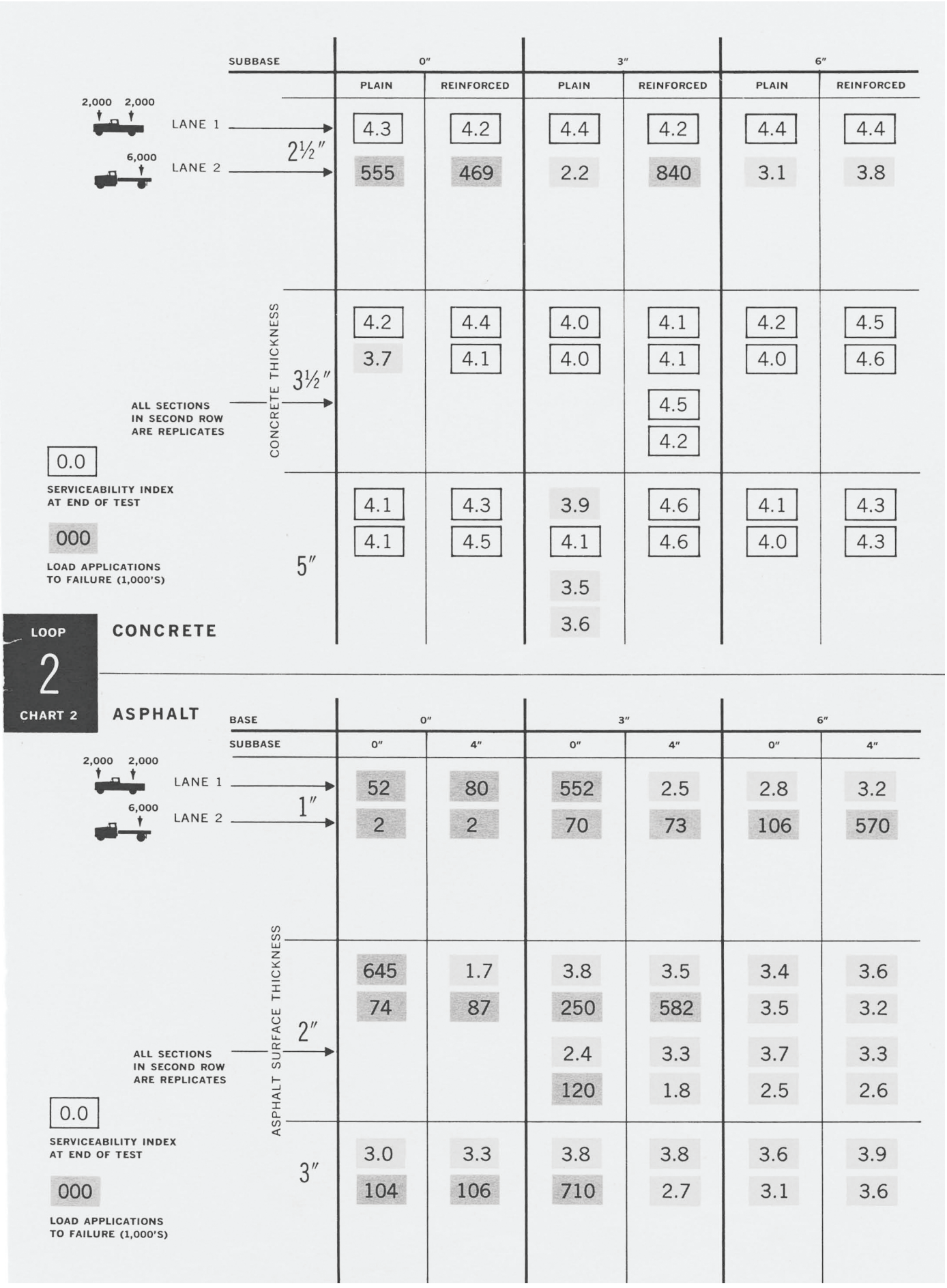
What about the asphalt designs? What are the minimums there? The *BLR Manual* says 3 inches on 8 inches of stone is adequate. So how do you actually compare these competing sections? Clearly, IDOT methods are not the answer!

There are a number of competing design systems for concrete pavement in this design niche. Many of you are familiar with the Concrete Pavement Analyst (CPA) software available from National Ready Mixed Concrete Association. It has been discussed on several occasions at the IRMCA annual short course, and seminars have been conducted on its use by your association. CPA is largely based on a variation of the results of the road test conducted by the American Association of State Highway Officials (AASHO). I will not go into detail here, but CPA uses a variation on the structural coefficient approach to assign a structural coefficient to concrete.

However, since the AASHO Road Test was conducted right here in Illinois, why not use the data, the methods and the equations laid out in the 1993 *Guide for Design of Pavement Structures*? If it is meaningful anywhere, it should be here in Illinois.

First, a little history. The engineers at the Road Test conducted testing on sections of both asphalt and concrete pavements under the same traffic loadings at the test site west of Ottawa, Illinois. Interestingly, some of these sections included loadings restricted to automobiles and light trucks; loads more typical of convenience store and mall parking lots. The concrete thicknesses on these sections ranged from 2.5 inches of concrete up to 5 inches. How did they fare? One of my personal favorites, an out of print publication titled *Pavement Performance in the National Road Test*, produced by Portland Cement Association in 1962 offers some insight. (I have a pdf if you are interested.)

Figure 1: Final performance of test section in main experiments



The tables in *Figure 1* demonstrate how the pavement sections performed. The tables are a little busy, but they are jam-packed with exciting information for pavement geeks interested in promoting concrete pavements for parking lot applications.

During the Road Test, vehicles ran over the traffic loops until the loops had received roughly 1,114,000 axle load repetitions or the pavement section had failed. Periodically, engineers at the Test Road would evaluate the serviceability of the sections on a 5-point scale, five being a smooth pavement in new condition and 1.5 having been determined to be failure of a section in need of serious repair. The vehicles ran in adjacent lanes restricting the specific loads to those lanes. In our table you will see that one lane operated with 2,000 lb. axle loads, the other with 6,000 lb. axle loads. By conducting the test in this manner it was possible to compare performance of different loads to one another while simultaneously evaluating the affect of those loads on different pavement sections. The asphalt and concrete pavements of different sections received identical loadings under identical traffic for roughly two years.

The tables depict the serviceability after 1M plus axle loads shown as a grade ranging from 1.7 to 4.4. If the section failed (i.e., reached a serviceability of 1.5), the number of axle-load repetitions in thousands is shown. In addition, various subbase thicknesses were evaluated for both asphalt and concrete. For concrete sections, mesh-reinforcement was also evaluated as that was popular at the time of the test. (Mesh reinforcement turned out to not make a difference, but that is perhaps an article for another time. Needless to say, we no longer use mesh in Illinois.)

Let's work left to right for the concrete section of Loop 2 and the 2 ½-inch concrete pavements. Yes, they tested them that thin. Serviceability of the pavement sections for 2,000 lb. axle loads similar to that of an automobile were in very good condition, i.e., serviceability greater than 4.0 after 1M plus repetitions. This was regardless of whether the pavement was placed directly on Illinois' marginal soils or with 3 inches or 6 inches of stone subbase somewhat similar to today's dense-graded granular CA-6 with a fairly high amount of fine material.

The 6,000 lb. axle loads pounded the section a little harder, but even here the 2 ½-inch concrete section still carried about 469,000+/- axle load repetitions. The stone helped some on these very thin sections.

What about the asphalt sections? They were tested under the same traffic and same weather conditions. Indeed, these were loops so the trucks ran on concrete on one side and asphalt on the other. Looking at the table we find some interesting comparisons.

From top to bottom on the asphalt section of the table it shows the thickness of the asphalt surface. The base and subbase as defined at the Road Test are a stone base and sand-gravel subbase; in simple terms, granular material. For 3-inches of asphalt on dirt carrying the rough equivalent of automobile traffic the serviceability of the asphalt was 3.0 at the end of the test. This compared to 4.3 for the 2 ½-inch concrete section under identical conditions. A fluke, right? How about the 6,000 lb. axle loads?

Careful inspection of the 6,000 lb. data indicates that for the same conditions described in the previous paragraph, the 2 ½-inch concrete pavements carried greater than five times the number of repetitions to failure as that of the 3-inch asphalt section. Checking the tables carefully you will find that, in general, the concrete outlasted the asphalt, inch for inch!

So, back to the original question: how would the sections compare using IDOT standards that an architect or engineer might pull off of the shelf? *Figure 2* shows the answer. The concrete sections, either the minimum that we normally recommend for parking lot section drives with low truck traffic or the IDOT section, will carry significantly more traffic than the minimum IDOT bituminous section.

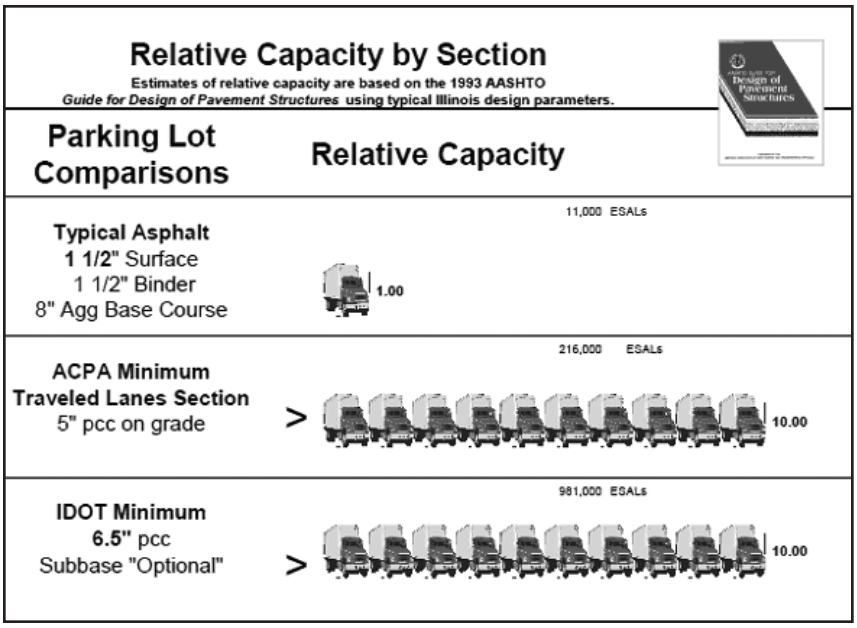


Figure 2

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