Flexible pavement design began centuries ago when boulders, gravel and logs were placed in the mud holes in order to stabilize the earth roads which carried the earlier forms of wheeled transportation. The search for better and more economical load supporting road surfaces has progressed through the years, and we now have a great variety of materials and construction methods to aid the designer.

Basically, a flexible pavement depends on the keying action of the aggregate, and the binding material used. Modern equipment produces crushed stone with ease in all desired sizes from dust to the larger three or four inch sizes. Gravel is similarly produced from sand size on up to the top size gravel available. Any hard substance that will stand the wear and disintegration tests may be used. To name just a few, we have limestone, granite, sandstone, river sand, river gravel, rock asphalt, slag, creek and bank gravel.

The pavement designer of today is indeed fortunate to also have a wide selection of binding agents. The tremendous development of the oil industry brought about by the automobile has provided for us an abundance of asphaltic materials suitable as binder material in a great variety of pavement designs. Rapid curing, medium curing and slow curing liquid asphalts, asphalt cements and emulsions are available in all grades. In addition to the asphalt products, other stabilizers are available such as the tars in all grades, calcium chloride, portland cement and lime.

It would seem that the design of a flexible type pavement would be a relatively simple matter when it is known that there are so many materials that can be successfully used; however, in many parts of the world, and in some areas of the United States all of these materials are not available except at prohibiting costs. Even in our own state which is blessed with a wealth of material, there are certain areas which must be studied closely for the use of local aggregates in order to hold costs down. The depletion of known aggregate sources is becoming a serious problem in several states now.

Experience and judgment designed all the flexible type pavements until very recent years. An increasing knowledge of soils and their classification by standard tests, along with standard tests for base and
surface materials such as density, wear and stability has stimulated the highway engineer to develop pavement design methods, which it is hoped can be used as safely and economically as structural design methods. It is recognized that because of climatic conditions and the variety of materials used, it will be difficult to develop a design method capable of universal use, but it is essential that one or more good design methods be accepted and placed into use if we are ever going to take pavement design out of the guessing game stage. The Committee on Flexible Pavement Design of the Highway Research Board is tackling the problem in earnest. During the past year identical samples of subgrade soil and base aggregate were sent to seventeen highway departments for analysis. Each department was asked to submit a pavement design for three different traffic conditions. Since it was realized that a comparison of the submitted designs could be embarrassing, the states were not identified except by a code number. Kentucky participated in this study, and we have asked that the study be extended, as did the other participating departments, for the reason that the range in pavement thicknesses reported was so great that everyone was concerned. Evidently, some of the design methods used are seriously in error unless they can be substantiated by more detailed information.

You will probably be interested in the Highway Department's method of designing new flexible type pavements. As you know, most of our high type surfacing follows about one or two years after the grade is completed. Three inches of loose traffic bound stone is placed on the grade and drain contract which permits the grade to be used by traffic and also adds to the stability of the subgrade. Minor reshaping is done to obtain a uniform section before the new base material is applied. Prior to setting up the surfacing design, the laboratory samples and tests the top twelve inches of the grade and furnishes the Design Division complete soil reports with recommendations concerning the handling of bad soils.

Seven years ago the Design Division began using the California Bearing Ratio method to assist in determining pavement thickness. California developed a set of pavement thickness curves for five traffic groups after extensive studies of existing pavements and testing the underlying soils by the CBR tests. It was decided to develop similar curves for Kentucky as it was believed we could be in error using data based on California's experience. The Research Division tackled the problem and after about two years of intensive work in the field and laboratory, they furnished a complete report with design curves which differed very slightly from California's curves. The traffic was
converted into equivalent 5000-pound wheel loads. This is essentially a means of including in the traffic factor the "weighted" effect of various sized wheel loads.

Several types of soil bearing tests were compared in the study and it was decided the C.B.R. method was the most practical. To show how difficult it is to design for the future, it was soon noticed that using 1960 traffic estimates, most of the primary roads fell in or beyond the highest traffic group curve in the research report.

We have adopted a policy on heavily traveled roads of using a minimum total thickness of eleven inches, and a maximum thickness of eighteen inches. Our curves indicate that for excellent soils we could go under eleven inches so this is our factor of safety. The curves show that extremely poor soils require as high as twenty-two inches of thickness. This is where we may be leaning toward weakness when we arbitrarily stop at eighteen inches of thickness. It is our intention to have a pavement condition survey made of all the flexible pavements designed by this method in a few years. We should then be able to re-evaluate our methods. Since the Construction Division has sent the laboratory samples of subgrade soil at 500 ft. intervals on all these projects just ahead of the surfacing, we will have about all the information needed. The construction plans will show the depth of surfacing at any particular station and the laboratory report will show the soils by stations. A mass of this type of information worked into a pavement condition study in later years should furnish first class data for the designer. He will also have, through the labors of the Planning Division, an accurate yearly record of the traffic.

The problem of getting reliable information for flexible pavement design is one shared by all road building agencies, and to get the answer quickly, several highway organizations are planning the construction of test roads or tracks on which trucks of different axle loadings will travel over pavements of graduated thicknesses until they approach destruction. Research of this kind is very expensive, and it is not too convincing when the test is performed hundreds of miles from your state, with different soils, climatic conditions, and materials.

The composition of high type flexible pavements in this state vary in many ways depending on the conditions, but the most frequently used design calls for waterbound macadam base in one or more courses topped with a 1½" binder and a 1½" surface of bituminous concrete.

For example, suppose a 15" total overall thickness is required, the typical section would show:

1" — Insulation Course No. 5 and No. 10 stone 50% each.
8" — Waterbound Macadam Base No. 1 stone and No. 10 stone (2 courses 4" each).
3" — Waterbound Macadam Base No. 2 stone and No. 10 stone.
0.25 gal/sy Tar RT 2 (for prime).
1½" Bituminous Concrete Binder Type A PAC-5.
1¼" Bituminous Concrete Surface Type B PAC-5.

In this design the 1" insulation course serves to choke the bottom of the waterbound against subgrade infiltration. The No. 1 stone is used on the bottom waterbound courses because of its better keying qualities. The top course is the smaller No. 2 stone, and it is used on top in order to gain a better riding surface. There is a considerable difference of opinion on the use of No. 1 and No. 2 stone, but it is believed this is caused by difference in gradation at the various quarries.

The bituminous mixes of all kinds, play a major role in flexible pavement construction and they all have their proper place in the picture. This is a subject by itself and no attempt will me made to discuss mix design. There are many engineers who believe that an inch of bituminous concrete is worth more than an inch of waterbound macadam, but this remains to be proven. The bituminous binder course has two main purposes, to take out small irregularities in the top of the waterbound macadam, and to provide a somewhat open surface that will permit the finer textured surface course to knit in and become integral instead of being distinctly laminated. On short projects the quantities of binder and surface course are insufficient to warrant setting up a hot mix bituminous plant, and in order to get a reasonable price on the bituminous concrete a course of black base is substituted for the last waterbound course. This design is usually employed on city streets and in addition to helping the riding qualities of the base the increased cost is small because of the larger quantities of bituminous mix. The mix design for the bituminous concrete surface course is of prime importance. This course must stand the wear, it must resist weathering, it should be dense but not slippery, and finally it should provide a smooth riding surface of good appearance. Careful mix design is required to obtain all the essentials of a good surface, but it is also necessary that extreme care be exercised during construction to preserve the delicate balance of materials specified.

The constant demand for hard surfaced, dust proof roads has caused thousands of miles of flexible pavement to be designed around the dollar instead of by sound engineering methods. The all too familiar black top road patched on top of patch must be considered a victim
of expediency, caused by lack of funds, and is not to be compared with a properly designed flexible pavement. These hopelessly weak pavements which comprise a large percent of the total mileage of surfaced roads have caused flexible type pavements to be criticized unjustly by the public. The excellent performance of some of the older roads of sufficient thickness, under the heavy traffic of the past ten years, has proven the worth of this type of construction.

I will not attempt in this brief paper to discuss the design of soil cement stabilized bases, bituminous or calcium chloride stabilization. We have constructed all of these pavements in Kentucky, and our experience has indicated that we can expect good results if we confine soil stabilization to the good sandy soils and stay away from the heavy clays.

The importance of soils in pavement design cannot be overestimated. A slight amount of precaution in placing the better soils in the top foot or two of the grade project will usually mean a saving of thousands of dollars when the surface is designed. To most grade and drain construction, engineers in the early years, all the roadway excavation was common earth or rock. Now that some of these men, including myself, have learned the importance of handling soils properly, we do not hesitate to preach the subject of soils. So our advice to the young highway engineer is do not become so entranced with running in fancy curves or staking our complicated drainage structures that you neglect learning all you can about “the good earth”, the foundation and governing factor in any type of pavement design.