I don't believe they were having Highway Conferences as such back several hundred years ago when a man named Bill originated the saying “Fools rush in where angels fear to tread” but I am sure that such a phrase must have entered the minds of many people when they saw the announcement for this part of the program today. At least, that was my own first impression and I can assure you that I've spent quite a few hours in the past weeks trying to figure out how I could say something that would be of benefit to some of you and at the same time would not make too big a fool out of me.

I hope no one has come here expecting to get a little formula that will tell you how many dollars to put into grading, draining, and surfacing. It would be worse than foolish to attempt any such thing for Kentucky with her 120 counties stretching from the Mississippi to the Big Sandy. No formula or set of rules could possibly be devised to cover the situation in Kentucky. We are faced with types of soil and terrain ranging from the coastal plain deposits of the Jackson Purchase to the solid rock of Pine Mountain Fault. As most of you know, these conditions and a multitude of others combine to make highway work in Kentucky and elsewhere a continuous series of compromises. This necessity for compromise was strikingly presented at our Highway Conference last year by Mr. Owen. One of the biggest influences toward compromise is the farmer or taxpayer who comes to your office day after day demanding that some money be spent on “his” road. You can tell this man that the longest road in the world goes from Someplace to Such and Such or that the widest road in the world is in a certain state and he may believe you, but he will NEVER believe that the most important road in the world is anywhere except right by his house.

All of you know, I suspect, that the chief highway problem in Kentucky and everywhere else is lack of funds, or how to stretch the funds available over the largest possible mileage consistent with good results.

With these facts in mind, I have prepared a few remarks more or less to refresh your memory on some of the cardinal principles of highway design and attempt to point out the penalty if such principles
are ignored. Now don't get the idea that I am talking about something like the Pennsylvania Turnpike when I speak of highway design. On the contrary, I am speaking of the 48,000 miles² of county roads that are the everyday concern of most of you here.

To start with, I think I shall combine my discussion of grading and draining. As you know, these two items are usually contracted for together on most secondary roads. I believe they are very much like husband and wife. It is dangerous to try and separate them. They are closely related. Before we get too involved with combined grading and draining, though, let us consider the problem of roadway width. Most people agree that widths less than 18 feet are inconvenient and in some instances unsafe. Now as an engineer, I would like to see wide, paved roads all over the state, but for the present, at least, that is a far distant goal. Practically speaking, the width of highway needed depends primarily upon the number of vehicles using the road. If that number is less than 100 vehicles per day (some of our roads average less than twenty-five per day), it is possible to get more miles of road by keeping the width down and at the same time provide for safety by providing plenty of "turnouts". These turnouts can usually be made quickly and cheaply with a bulldozer. Some standards on this subject are set too high since many county roads are low speed roads used almost entirely by people completely familiar with them.

Now let us think for awhile about drainage. Water is any road's worst enemy. If you are to have a good serviceable road, you must keep water off of the surface and out of the subgrade. To have good drainage, therefore, your road must be graded and shaped so that water falling on it or running on it from higher land will drain away as quickly as possible.³ The foremost fundamental of all road and highway design is good drainage. The principal rewards of good drainage are longer life and less maintenance cost for a road. And let me emphasize the importance of those lower maintenance costs. Once all those good new roads are built, the farmers and taxpayers are going to insist that they are kept in fair condition. There is all the time a tendency for maintenance costs to take up an increasing percentage of highway funds. That trend must be slowed if possible. The penalties of poor drainage are many and well known. Some of them are erosion, wash outs, soft spots, mud holes, failures of wearing course due to lack of subgrade support and so on.

The best time to achieve good drainage is undoubtedly during construction. So let us study for a moment how to obtain good drainage.

¹ Numbers refer to bibliography at end of paper.
In other words, let us build it right. To begin with, highway drainage may be divided into two main systems: side drainage, consisting mainly of ditches and driveway pipes, and cross drainage which consists of pipes, culverts, and bridges to carry the water across the roadway at natural drains. In new work, your ditches should slope away from the road as gently as possible for safety’s sake and for ease in mowing and maintaining them. At the same time, they must be made deep enough to carry the volume needed. To cut down water damage to the ditch itself, the gradient of the ditch line should be kept as low as possible. This may be done by ditch checks and frequent cross drains.

It is sometimes possible to save money with no sacrifice in result by ditching only the high side of the road.

When we consider cross drainage, let us look first at the smaller structures such as pipes and box culverts. A pipe or culvert should be placed in every natural drain that will lead water away from the roadway. Pipes should be laid low enough to have good cover and in this connection, if problems of limited fill occur, a good solution may often be found in the new flat bottomed metal pipes now on the market. Several pipes together may also be used if used with a proper headwall. A headwall of some sort should be used on all pipes if possible. If this isn’t feasible, they should at least be protected by a guard post to prevent damage by maintenance units such as graders and mowers.

The matter of cross-drainage in new construction when large structures or bridges are used is largely beyond the scope of this paper but a few points to remember present themselves. Here, more than any other place, you should “build for the future”. Some experts are predicting that we will have 50,000,000 automobiles on the road by 1950. We now have about 41 million cars so that would mean an increase of over 20%. A lot of those extra cars are going to belong to the people on the farm. They are going to be running on our county road system. The span length is the primary factor in the cost of a bridge and the cost of building a few feet wider than your present needs will not be much extra and will be far less than building a new one 10 years from now. Wide bridges are a safety asset and the old rule of building the bridge at least four feet wider than the roadway is a good one to remember.

In summarizing drainage in new construction, then, we can say (1) build the best road you can afford (2) be sure that the standards you use are not too high and (3) remember that the best road is usually the best drained road and that with some soils and terrains, a county road can best be built by following the contour of the hills and borrowing good dirt for fills.
So much for new constructions. Most of you are going to be faced with a different problem though, that of reconstructing as many miles as possible of existing roadway with the funds available. How are you to balance the costs of the various items on these roads? Let us start by looking at our side ditches again. The same principles as for new construction holds true. Flatten the side slopes and put in frequent cross drains to cut down water damage.

When it comes to cross-drainage by pipes and small structures, however, two things may be done. First, more pipes and culverts may be added at needed points. Secondly, since the reconstruction of old roads usually involves widening, several things may be done if the existing drainage facility is in good shape. Pipes may be lengthened by fastening short lengths of metal or concrete pipe onto the existing pipe. This procedure usually works best if it is done on the entrance end of the pipe. Some box culverts may be lengthened by concreting a length of pipe into the present opening. Some states have reported considerable success in lengthening box culverts by means of creosoted timbers and pilings. This extension is usually placed on the inlet side and is flared to resemble a funnel.

We come now to perhaps the most serious problem in the whole field of highway transportation. What can we do about sub-standard bridges on existing roads? Replacement of bridges costs money and plenty of it as you all know. As a matter of fact, it would take approximately ten years of rural highway funds simply to replace all bridges that are sub-standard either in width or load carrying capacity. On January 1, 1938, the Highway Planning survey reported that out of Kentucky's 5,129 bridges, 4,602 of them were less than 16' wide and of that number 1,436 or 32 percent were in poor condition. That was twelve years ago; how many are now in poor or worse condition after a war and the readjustment period which followed? What are we to do? Further neglect may conceivably lead to a complete breakdown of our secondary road system. We don't have the money to replace them in a year's time even if that were possible. The only thing we can hope to do is to set up a long range program and hope and pray for the best. Each of you should inventory your own system and see what the score is if you haven't already done so. I am told that the State Highway Bridge Department is now engaged in analyzing structurally a number of bridges over the state. So it may be that they can tell you if certain bridges can be repaired and used for a while longer. But certainly a number of bridges are going to be found to be past redemption. Those will have to be replaced. Some of your money is
going to have to be allotted for this purpose or you will find yourselves with a number of short pieces of good roads resembling pieces of chains with broken links where the bridges are supposed to be.

Other bridges can possibly be repaired and widened. This problem is not peculiar to Kentucky. It is almost nationwide. Other states have repaired and widened old bridges by use of timber pilings, and timber reinforcing. Steel I beams have been used in a number of cases on short spans. A lot of things can be done to repair old bridges but each case is, of course, a separate program requiring thought and good engineering.

The penalties for neglecting this condition are many and severe. A complete breakdown of your road system is not impossible. Maintenance may be seriously retarded because bridges won’t carry trucks of gravel, or even patrol graders. Viewed from the safety angle, you may create a death trap when you improve a road and leave a narrow, weak bridge standing as the weak link in the chain. Most everyone, particularly the younger drivers, speed up when they get an improved stretch of road. The fact that a road is familiar is no insurance against accident.

Perhaps that is enough about grading and draining. Let us look for a moment at the problems of surfacing our county highways. I doubt if there is anyone present today who needs to be “sold” on the beauties and advantages of a smooth-riding, dustless, mudless, all-weather surface. We would all like to have all of our highways paved in some manner. The type of surface required on a roadway depends primarily upon the volume and kind of traffic which will use the road. Such factors as type of materials available locally and the climate also enter into the selection of a surface type. Most of our county roads are of the crushed stone, traffic bound type, and in most cases, this surface is no doubt the best available for the purpose.

There are two cases, however, where other surface types may be more economical. First, if the traffic volume on a road is less than 25 cars a day and soil and terrain conditions are favorable, some sort of stabilization, such as road oil or CaCl₂, may possibly prove more economical and at the same time give a fairly reliable all-weather road. This is worth investigating.

The second case is more common. It comes about when traffic bound surface is being worn away at a rapid rate. In that case, a few calculations may show that a low-cost bituminous surface treatment or surface will pay for itself in decreased maintenance costs and the like.

Now in conclusion, how are we going to balance expenditures for
grading, draining and surfacing? The answer is this: if you provide adequate drainage on every mile of highway you build you will have more money in the future to build more highways with because your drainage money will be returned to you many fold in increased life of your roadway and wearing surface and in decreased maintenance costs.

**BIBLIOGRAPHY**


