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For the next quarter of a century the building of highways will be the biggest constructive activity of the American public. This will be true measured either by the appropriations made to pay the cost or by the percentage of the population upon whom will be exerted some influence and to whom it seems certain some benefit will accrue. The biblical description "Oh, ye of little faith," has been true of about 90 per cent of the people who would stoutly maintain their right to be classed as apostles of good roads. Too many men have expressed their forlorn wish that they should like to have good roads to use during their lifetime, and too few of these have had any thought that their wish would come true. There have been a great many doctors of roads. There still are. While the symptoms have been generally agreed upon the diagnoses have divided men into opposing camps. A good deal of the past road history has been aptly described by Mark Twain's statement concerning the weather, that "nearly everyone discusses it, but no one does anything about it." Recently, however, something big and real has been done to make definitely certain the securing of adequate roads. We have convincingly answered the question whether we are going to build roads in the affirmative. We are perhaps more uncertain about the kinds of roads we will build. If, under some Utopian condition which the road engineer has hoped for, there might come a discussion of the question of road improvement without so many doctors who insist upon their opinions being followed in the choice of the materials for the roads which are to be built, the result would be far better than at present.

Many selfish opinions lead to delays and very often to poor selections of the roads for which the public expends its money. We have not yet learned to impose sufficient confidence in men whose training and experience have qualified them to advise rightly, and too often the selection of the kind of roads to be built has been determined by superior salesmanship or maneuvering of votes than by the merit and quality of the particular kind of road.

Some of these things are gradually clearing up. For the holiday season of 1920 there can be some distinctly hopeful thoughts of the future, for the States and the Federal Government have joined hands in the building of highways. For the first time in the history of the country we are able to say that we are actually building roads up to the economic capacity of the country, that our progress in actual miles of successful highways is no longer limited only to a desire for them. A definite nation-wide program of highway improvement is under construction, so large that it is questionable whether this year we will be able to complete more than 50 per cent of the actual contracts which we have under way and had hoped would be ready for the stockings of the nation.

The Federal Aid law, by which the Federal Government instituted a program of highway improvement, was enacted in 1916, under which, up to the limit of the appropriation, it agreed to pay not more than 50 per cent of the cost of the highways to be built in cooperation with the States. An appropriation of $75,000,000 extending over a five-year period was made. The Federal program is administered by the Secretary of Agriculture through the Bureau of Public Roads, and in each State

is a State highway department, and all contact between the Federal Government and the State is through this department. The first appropriation was not sufficiently large to serve a real constructive purpose. Also, there were certain severe limitations in the original law. These were remedied in February, 1919, by broadening the application of the law and increasing the appropriation by $200,000,000, to be available over a three-year period. At the end of the last fiscal year, June 30, 1919, road projects had been approved whose total estimated cost was $384,916,819. Of this amount $163,841,503 was apportioned from Federal Aid funds.

We have looked upon the construction of the Panama Canal as an immense task, and we have been proud of its successful completion. The estimated cost of the roads covered by the above project is greater than the expenditure for the Panama Canal. The distance in mileage would reach between New York and San Francisco, across the continent nine times. Not all of this mileage is under construction, but it is definitely provided for through agreements, and the actual construction is being undertaken as fast as the economic limitations can be overcome. At the end of the fiscal year there were actually under construction approximately 15,944 miles of road, and approximately 5,500 miles have been completed since the inauguration of the Federal Aid plan.

Frequently the statement is made that a very large mileage of the low cost roads such as earth and gravel, are being built. This is quite true, but it does not correctly represent the expenditure of the funds. More than 60 per cent of the total appropriations involved will be spent for the more durable types of highways, such as bituminous concrete, Portland cement concrete, and brick. Nine per cent of the cost will be invested in intermediate types, such as water-bound macadam and bituminous macadam, while 25 per cent will be invested in earth, sand, clay and gravel.

It is perhaps unnecessary to dwell further upon any proof that the public has gone into this business of road building seriously. It may be germane to add, however, that without exception every State is functioning through the State highway department, which is largely made up of engineers experienced in highway construction, and the plans and specifications adopted for the highways by the States must also pass the scrutiny of, and be approved by, the Federal Bureau of Public Roads, under certain standards which have been established. The work which is being done under this organization, however, comprises only the State and Federal highway work, and in many instances there are large local programs of highway improvement included which are not governed by either Federal or State specifications.

It appears, therefore, that a plan of organization is being rapidly perfected in a manner that will guard the public's interests and insure a competent expenditure of the State and Federal funds.

After having made large appropriations available, and having planned an extensive organization to carry on the program, it is to be expected that the next question to be settled is, what kind of roads are we going to build. Also, what is the best kind of roads to build. The general answer to the first question is easy - all kinds. There is no answer to the second. That is, there is no single answer. There is no answer that would be true generally

any more than there is a single answer to the question, what kind of an automobile is the best for a man to buy. It is right here that the doctors disagree, because the remedy prescribed by each one is probably correct for some specific case, but is certainly not a panacea or cure-all, and none such exists.

There is one all important guide board to the only avenue of approach to this question. It reads: What service do we and will we expect to receive from this highway? The answer to this question is vital - in the selection of types of road to build and the determination of a road program, whether it be for a community, state, or nation. Let us examine some of the facts. The cost of a road is not made up alone of the contract price. It must be maintained and rebuilt if necessary, and the interest charges must be paid. We expect to have on the highways of this country before the end of the present year approximately 8,000,000 registered motor vehicles, of which probably not less, probably more, than 1,000,000 will be motor trucks. The proportion of trucks to passenger cars will be about as 1 to 7. It is apparent from the rapid increase in the building of motor trucks that their use and number will be greatly extended. The automotive industries estimate that more than 300,000 motor trucks were built during the year 1919. It has also been estimated that of the total motor vehicle registration in 1919, 2,366,175 were farm-owned. Of the motor trucks manufactured in 1919, it is estimated that less than 7 per cent were above 2½ tons capacity. Detailed studies of motor trucks in use made by the Department of Agriculture on over 700 farms in the Eastern States revealed the fact that the rated capacity of very few of these trucks is greater than 2 tons, and nearly half of them are of the 1-ton size. A similar study made of over 800 farm-owned trucks in the corn belt States revealed the fact that the rated capacity of the trucks varies from ½-ton to 2 tons, and experience has caused 57 per cent of the owners to decide that the 1-ton size is best suited for their conditions, 25 per cent that the 1½-ton size is best, and 12 per cent that the 2-ton size is best. In this study only 14 per cent were less than 5 miles from the market, and 20 per cent were 15 miles or more from the market. It is not presumed that these figures are final, but apparently they are indicative of the trend in the development of the use of motor vehicles for some time to come. In a very general way it appears that only a comparatively small percentage of the trucks which are now being manufactured have a higher load capacity than 2 to 3 tons, and that the favored sizes for the farms do not run above 2 tons capacity. It is also apparent that the larger trucks will for some time be used primarily in the cities and in the districts around large centers of population.

Experience has very definitely shown that the maximum loads which the roads are compelled to carry determine their durability rather than the number of light loads which will go over them. In other words, while the passenger-carrying vehicles provide more than 90 per cent of the use of the highways, the necessary strength of the roads will be determined by the truck traffic, which constitutes now less than about 10 per cent of the total traffic.

So it is apparent that the types of roads in any locality will be determined largely by the provision that must be made for the truck

traffic.. Careful measurements by the Bureau of Public Roads have shown that a loaded truck carrying a five-tonload standing still on a road surface of some rigid material such as concrete slabs having a thickness of, say, 8 inches, is very easily supported by the strength of the slab, but the same truck operated at ordinary speeds may cause trouble very soon. This led to a very careful study of the impact or blows struck the road surface under truck traffic. The results of this study have brought out astonishing facts which explain very fully why there have been so many failures of what were regarded as first class road surfaces. It has been shown, for instance, that the blow struck by a truck wheel on a road surface when there is a small obstruction, such as a slight depression or elevation in the surface itself, where the truck wheel is shod with a solid rubber tire may be equal to three times the load on the wheel when standing still. As soon as a slight break is made in the road surface every vehicle that passes adds its blow to those preceding, and the disintegration of the surface increases more and more rapidly. The effect of these blows on the road surface is not confined to the breaking down of the surface alone, for there is the added shock to the earth sub-grade which supports the surface. If the sub-grade is not firm, dry and hard, and capable of resisting these blows, the whole surface is beaten down into the road grade.

Coincident with the tests which have been conducted, careful field studies have been made of road failures which have resulted. These studies are being made on a very extended scale and cover all sections of the country. Without going into a lengthy discussion of the results, it has become very apparent that if we are to build highways that will prove adequate we must consider not only the service which we will demand, particularly the number and weights of the trucks which we expect to carry, but also the character of the soil over which the roads are to be laid.

In the older established communities, particularly of the East States, where the highway pikes or grades have been built for a long period, where the sub-grades have been thoroughly dried out and compacted under years of traffic, modern types of road surfaces can be built successfully, and the record shows that in these States a very large percentage of the funds are being expended for paved roads of durable types. Here also are the largest concentrations of population, and here will be demanded for some years to come the greatest service from the highways by the heavier trucks. Largely on the main roads of these States the pavement construction is replacing gravel, stone macadam, and similar surfaces which are not adequate for the present traffic. Over these old gravel and stone roads the modern types of paved surfaces can be built with considerable assurance that these pavements will safely carry the loads which should be placed upon them.

In the Central and Middle Western States along the main lines of travel which form the backbone of adequate state systems, the paved types of highways are being built and will prove the most economical, but here there is a particular need for a very careful study of the soils and sub-grades over which these pavements will be built. Many miles of highways will be built on sub-grades which have not been solidified through years of use and which have not been so carefully maintained that the bad wet spots and seeps have been thoroughly tiled out and drained. The heavy black or clay soils and

the gumbo soils are particularly treacherous when wet. They are very stable and can carry heavy loads when kept thoroughly dry. Unless this condition can be secured it will be necessary to build much greater thicknesses of surfacing than has been customary in the past. Drainage when applied to roads must mean something greatly different than when applied to agricultural lands. It is not sufficient to remove water after it is once in the road grade; it must not be allowed to enter; for example, we have records of the failures of first class road surfaces due to seepage underneath the pavement from the edges. The sub-grades upon which our roads are to be built are so highly important from the standpoint of the durability and life of the surfaces which are placed that it would be very desirable if, in the Corn Belt, roads could be drained, graded, and compacted thoroughly under traffic before any attempt is made to lay the permanent surfacing, but there is the traffic here now to be carried, and such a plan cannot be always followed. In these States, however, a large mileage of highways is being built on which a gravel surfacing is being placed. Such construction under patrol maintenance can be held up under traffic incidental to purely agricultural communities, and while there still remains such a large mileage of unimproved roads there can be no criticism of this policy. Where local gravel or similar deposits of material exist, advantage is being taken of this plan by many of the Middle Western States. It is a far better plan to build highways of this character and after a period of several years' use add a durable surfacing of modern type pavement than to attempt a compromise by which a light, inadequate pavement is built. It is impossible within the scope of an article of this character to lay down the dimensions or details of construction of the roads that will prove most economical, because these details must be governed by the conditions applying to the individual cases, but in these individual cases the fundamental question remains the same, what service will we require of the road.

The Federal Aid program is largely limited to the building of the main State highways, and it has already been stated that over 60 per cent of the funds which have been allotted to specific projects are for the building of durable paved surfaces, but approximately sixty-six per cent of the mileage is of the lower type roads, such as earth, sand-clay, and gravel, and these percentages well illustrate the problem which confronts the State and Federal authorities. It may be stated in this way. In those communities where a large truck traffic will develop immediately after roads are built and where there will be a considerable use for trucks of the heavier types, the paved surfaces will prove the most economical over a period of years if built sufficiently strong to support the loads. The thicknesses of these surfaces will be seriously modified by the character of the sub-grades over which they are built, and unless this principle is adequately met the construction will not prove satisfactory. In localities where there now exists a large mileage of unimproved roads of any character, and where the traffic is largely that of agricultural communities, the lower cost roads should be built until the traffic increases to such an extent that they can no longer be economically maintained.

The most serious general need which we have is that of more adequate maintenance. It is being thoroughly demonstrated that even the best roads will deteriorate seriously without adequate maintenance and that the poorer roads can be held up under very considerable traffic where the roads are placed under a constant and sufficient system of maintenance.