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Address before New York Institute of Consulting Engineers.

It is true that we have spent large sums for road construction, and it is true that we do not now possess the full value of our expenditures in adequate highways. But should we actually expect to find the full value in such an inventory?

If you should take time to calculate all of the money you have spent to clothe yourself, and should compare the sum with the value of the clothing you now possess, you would be astonished at the result. But, though the value of the clothing you now have is but a small part of the expenditure you have made for this purpose, the expenditure has not by any means been lost. It has been a necessary living expense. The figure of speech is a homely one, but have we not been doing much the same thing with our highways? Our expenditures have kept us in roads - roads which have carried our traffic from year to year until this year we will carry nearly 8,000,000 motor vehicles in addition to horse-drawn traffic.

I will not try to answer all the arguments that have been advanced here, but there is much in the recent advances we have made to give cause for a decidedly optimistic feeling about the future of highway development in this country.

There are, however, many things that we must do, and it is a great pleasure to meet with the membership of this Institute who should be able to direct attention toward these things which are necessary.

The problem of highway building and maintenance has not had the proper amount of attention from the engineering profession, but we can believe we are now going to make up for some of this neglect because now, for the first time, there is a united public opinion supporting us, and we are able to do the things which long ago we knew should be done.

Some of these things I wish to outline, if you please, in a program which I think you can support, and I hope that what I shall have to say will be sufficiently constructive that when you go away from here tonight it will not be possible for any of you to say of our highway situation as Mark Twain remarked about the weather - "that everybody discusses it but nobody does very much about it."

First, let me direct your attention to the nature of our problem. It is not a question of whether we shall build brick highways or asphalt highways or dirt roads. What we are trying to do is to provide service - adequate highway service - and the engineers of this country must provide this service with all types of roads, but in any case the roads they build are going to be the very cheapest that will satisfy the demands of 8,000,000 motor vehicles, as well as horse traffic.

We are working under a pressure difficult to resist. We are not so fortunate as the early railroad builders, who had simply to build a line of railroad and carry over it a traffic which they could control, and which, indeed, they must need build up by colonization.

We do not have to wait until our traffic is developed - we have it thrust upon us with 8,000,000 motor vehicles demanding better roads. Nevertheless, we must take the time to do the things which are set down upon this program of which I am going to tell you, all the time bearing in mind that our real problem is the furnishing of highway service.

The specific problems which are raised by this heavy traffic so suddenly thrust upon us are: first, those relating to road construction and maintenance - the technical engineering problems; second, those relating to those qualities of the roads which are determined by characteristics of the traffic - by the operating requirements of the traffic - in which we are concerned with the type of the road, maximum and minimum grades, the elimination of rise and fall, and curvature; third, those problems of economic value. Thus we have separated all our problems into three groups, and in regard to these three groups we have two major responsibilities, as I see it. First, we must develop certain fundamental information; and second, we must disseminate that information - we must put it into the hands of the men who will use it in building up this highway service, which is our objective.

Although it is not directly under discussion here, I shall first touch briefly upon the second of these responsibilities, that of dissemination. Believing that there are not now a sufficient number of trained highway engineers in this country to supply the demand for men to supervise the construction of highways as rapidly as we need to build them, the Commissioner of Education called a conference at Washington in May of this year. The conference was attended by prominent educators and engineers and representatives of the automotive industries.

This conference concluded that in order to build up a sufficient body of trained engineers capable of guiding the development of our highways, it would be necessary to give more weight to the study of highway engineering in the curricula of our colleges and technical schools, and perhaps to go clear back to the high schools to begin the course of training.

As a result of the conference a permanent committee was formed, of which the Commissioner of Education is Chairman, and on which are represented the educational institutions, through the Society for the Promotion of Engineering Education; the War Department; the Bureau of Public Roads; the automotive industries; and the Association of State Highway Departments. This Committee has held several meetings which have resulted in the formulation of plans to interest the public in proper highway engineering and transport education and to develop our educational program for the dissemination of necessary information.

As an illustration of the methods that are being employed, a series of road conferences will be held at the University of Pittsburgh on the day after Thanksgiving Day, to which will be invited the road builders of the State and surrounding section, the teachers, the road users and the public generally. The meetings will be addressed by men qualified to present the various subjects of road construction, maintenance and administration, and the responsibilities of the road users and public in connection with road construction; and those in

attendance will be urged to take an active and responsive part in the program.

I mention this simply as one of the means of bringing the problem to the attention of the public and those it is particularly desirable to interest. A number of committees have been formed under the permanent committee, and these will serve in various ways to keep the attention of the colleges and engineering institutions focussed upon the necessity of training men for highway work. They will also serve as the medium for the dissemination of information which has already been gathered and which will be gathered by the several agencies cooperating in the movement.

Taking up the development of fundamental information - already a considerable amount of work has been done by the State highway departments, the Bureau of Standards and the Bureau of Public Roads. Under Mr. Page a great deal of work was done by the Bureau of Public Roads in devising methods of laboratory control of materials. This work was of such basic character that, although conditions have since changed very greatly, it was still of great value when the testing engineers of the State highway departments and the Bureau of Public Roads met recently to revise the standard methods of testing highway materials. The standards adopted by these gentlemen cover the testing of practically all highway materials, and represent the most approved practice. They will be published very shortly by the Bureau of Public Roads.

This work has been so well done that it is not now one of our major problems. What we now need most of all is research to develop better methods of highway design and to bring out the economic relations between the cost of highway construction and the operation of highway traffic.

It is highly desirable that these researches should be conducted on a national scale - that every agency capable of assisting in adding to our knowledge of these matters should be brought into cooperation, and its efforts directed by some coordinating agency to develop the essential information without lost time or duplication of effort. The one agency which seems best fitted to correlate and harmonize the individual efforts is the National Research Council. Indeed that body has already outlined a program, and appointed committees to do this very work. One of the Committees, that on the economic theory of highway improvements under Professor Agg, of Iowa State College as Chairman, has already done a great deal of work. The other committees are: the committee on structural design of which Mr. Goldbeck, the testing engineer of the Bureau of Public Roads, is chairman; and the committee on road materials, with Mr. Mattimore, the testing engineer of the Pennsylvania Highway Department as chairman. These committees have all started work and some of the results are ready for publication.

The section of the Research Council to which these committees report is the Engineering Division represented on which are such groups as the American Society of Civil Engineers, the American Society for Testing Materials, the Western Society of Engineers, the Society of Automotive Engineers, the American Association of State Highway Officials, the Bureau of Public Roads, and a number of others. It would seem that this Institute should be a member.

In connection with the highway research, it is proposed to form an advisory board, not of three men as has been proposed here, but a board composed of representatives of each of the large national groups interested.

Under this advisory board the detailed researches will be conducted by the several agencies which they represent, but each one will occupy a definite place in a well defined, comprehensive research program, conceived along the three lines I have mentioned - that is, construction and maintenance problems, operating problems, and economic problems.

I presume that the notices have already gone out to the several agencies I have mentioned, asking for a conference here within the next month. The progress reports which will be read at this meeting will constitute virtually a complete survey of the research work which has already been done and which is now under way; and I should regard it as highly desirable that this Institute should be represented.

As an illustration of the character of the work that has been done let me describe very briefly a series of tests which are now being made by the Bureau of Public Roads. As you are aware, one of the most destructive forces with which we have to deal in the design of our highways is the impact of heavy motor trucks. We have known this for some time, but heretofore, our knowledge has been of the most general character. The tests we are now conducting at the Arlington Experimental Farm are revealing most valuable information as to the intensity of the impact caused by vehicles of various weight operated at varying speeds, with different loads, and distribution of load, and with different proportions of sprung and unsprung weight. The method we are using is similar to that by which gun pressures are measured at the Frankford Arsenal. It involves the use of these heat-treated copper cylinders, a half-inch high and a half-inch in diameter (indicating). By a suitable contrivance the impact of the truck is delivered to a cylinder, which is deformed by the blow, and the amount of deformation is a very accurate measure of the intensity of the blow. This flattened cylinder (indicating) has been subjected to the impact of the rear wheel of a five-ton truck running at 15 miles per hour and dropping on to the cylinder from a height of one-quarter inch. By the comparison of the deformation resulting from the impact with the deformation under static loads, we have found that the effect of the blow in this case was equivalent to the effect of a static load of something like 28,000 pounds, which is about three times the static load on the wheel which delivered the blow. We have conducted thousands of these tests, until we can predict very closely what blow a given truck will deliver whether it drops an eighth of an inch or three or four inches, and whether it is travelling at 5 or at 15 miles per hour.

We have conducted another series of tests in which we have applied impacts of various intensities to road surfaces of different types; and as a result of these tests, I think we can say very definitely, right now, what thickness of slab of a given type is necessary to carry a five-ton truck - at least we have established certain limits.

In California we are conducting a study of the entire State highway system. We are concerned there not only with a study of the

adequacy of the roads that have been built, but with problems of maintenance and economics on a large scale. We find that some sections of the roads have broken down, yet we are not at all convinced that they have not been a good investment. All of us know that it is better to have some of our structures fail than to spend so much money that none of them can ever break down.

These are things which the Bureau of Public Roads has done. The Bureau of Standards and the various State laboratories have also made valuable contributions. You will see therefore that much has been accomplished. The plan now is that with these things as a basis we will go on to the establishment of new facts in accordance with a national program under the Research Council, extending our studies far enough to include every state and every kind of condition.

In this connection it must be borne in mind that road problems are essentially local problems in their details. Soil and other local conditions enter into them to such a degree that research carried out at one point is only generally applicable to other conditions.

I may say that at the present time we are arranging to establish a laboratory in one of the Western States, not to find out how to build roads of such high types as you require in New York State, but to find out how to build cheap roads properly. There are places in our Western country where the roads do not carry more than 15 automobiles a day. Yet roads must be built to accommodate what traffic there is, and I am convinced that we do not know all, by any means, that we should know about how to build roads for such conditions.

However, to revert to our program of research - I have described a few of the things that have been done. In general they are in the nature of accelerated tests conducted on a comparatively small scale. This work does not cost very much, comparatively, but in carrying the work further some tests will be necessary which it will be very expensive to conduct. I have referred, for example, to the tests we have made to determine the effect of impact on various types of pavement. These tests have been conducted on comparatively small slabs. We can select from these tests a type or several types which give promise of adequate service, but to verify our conclusions it will be necessary to make observations upon these types under actual, albeit controllable traffic. We are going to do precisely that. At this time the State highway department of Illinois and the Bureau are building in Illinois a two-mile section of experimental road which will be surfaced with a number of types of surfacing material; and as soon as the road is completed we will subject it to forced traffic, if you please - not ordinary traffic, but a truck traffic running at certain prescribed rates, loaded with certain prescribed loads, with all conditions controllable.

When we go into experimental work on that scale it will require a great deal of money. It will take so much money that it is not likely that any one agency can supply it, but all of us working together can furnish the means - and not only the means but the diverse points of view that are so essential to a proper solution of our problems.

The National Research Council is simply the coordinating body which will direct the attack of the various agencies to the points

where they can do the most good. This Institute can contribute a great deal for the public good, by taking an active part in this movement. It is not money that we are asking - you can contribute your services. In that way it seems to me you can best make your influence felt, and in that way you can do more than in any other to bring about a development of the highways of our country which can reasonably be expected to meet our requirements.

The Bureau of Public Roads has regarded this, the national program of research on highways, as of so much importance that we should lend ourselves as part of the big organization; that is, submerge our identity in a big organization that is being formed to carry this on. We have certain appropriations that can be used for this work. Also, we are cooperating with the Bureau of Standards, for instance, in the California investigations - the laboratory work is all being done in the Bureau of Standards' laboratories there, and they have already done a considerable amount of soils work. We expect to make use of all the soils investigation work, which we consider of utmost importance from whatever source obtainable, and go on from that point and incorporate it in this program.

It would be most gratifying if your Institute would see fit to appoint a committee to make a visit to Washington and to go over our experiments there. This is a particularly favorable time. You can see the slabs that have already been broken, and the work that is contemplated on beyond. We have built the slabs six months to a year ahead in order to be sure they attain their full strength.

We should be more than glad to have your whole membership come down, but assuming that would be an impossibility, we should be very glad if you would see fit to appoint a committee to make an inspection with the idea of offering constructive criticism.