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THE BUREAU OF PUBLIC ROADS

The most important work of the Bureau of Public Roads is the supervision of the cooperative construction of roads by the States and the Federal Government. This work is carried on under the Federal Aid Road Act of 1916 as amended by the Federal Highway Act of 1921 and other amendments. In this work and the closely related work of improving the main roads of the national forests, it supervises an annual program of road construction involving upwards of 8,000 miles.

It is also an agency of highway research, and the results of its investigations, conducted independently and in cooperation with State highway departments, universities and engineering experiment stations, are applied directly for the improvement of its own large construction operations. Applied also in the construction of the thousands of miles of new roads constructed annually by the States and counties, the improvements in road design and in the quality of highway materials made possible by its researches are of direct benefit to all classes of road users.

Through its Division of Agricultural Engineering it also conducts research directed toward the solution of the numerous engineering problems of agriculture, associated with the irrigation and drainage of farm lands, the design of farm structures and the application of power to farming operations.

Created in 1893.

Under the name of the Office of Road Inquiry, it was created in 1893 by the Secretary of Agriculture to carry out an Act of Congress that appropriated $10,000 to enable the Secretary "to make inquiries in regard to the systems of road management throughout the United States, to make investigations in regard to the best methods of roadmaking, to prepare publications on this subject suitable for distribution and to enable him to assist the agricultural colleges and experiment stations in disseminating information on this subject * * *".

From the date of its creation until 1912, its functions were those of investigation and education only. During this period, the Bureau and a small but growing group of pioneer State highway departments redeemed the processes of road building from the depths of futility into which they had fallen in nearly a century of unintelligent direction and laid the foundations of modern scientific highway construction.

It was the Post Office Appropriation Act for the fiscal year 1913 that launched the bureau upon its new career of responsible road building. The act provided an appropriation of $500,000 to be expended by the Secretary of Agriculture in cooperation with the Postmaster General for the improvement of post roads to be selected by them.

This initial experience in the administration of large construction expenditures was of great value to the bureau when,

as a result of the passage of the Federal Aid Road Act it was called upon to cooperate with the highway departments of the several States in a larger program.

Federal Aid Road Construction.

In recent years funds have been provided for this work at the rate of $75,000,000 a year. For the fiscal years 1931, 1932, and 1933, the amount has been increased to $125,000,000 annually. These funds are apportioned among the States and the Territory of Hawaii in proportion to population, area, and mileage of post roads, and are available for use only on the Federal-aid system which has been designated jointly by the States and Federal Government. The State highway departments initiate projects, prepare plans, and let contracts and supervise construction, all subject to the approval of the Federal Government.

Federal participation is, in general, limited to 50 per cent of the cost of construction and not to exceed $15,000 per mile. The Government does not contribute to the maintenance of the roads built, but each State pledges itself to maintain them and the bureau by regular inspections directs attention to needed repairs, which, if they are not made by the State in a stipulated period, it is authorized to make itself at the expense of the State.

The bureau administers this work from headquarters at Washington through eleven district offices. Seven of these re-

port directly to Washington and four of them to regional headquarters at San Francisco. Branch offices are maintained in most States to keep in close contact with the work.

Due to variations in available materials, climate and traffic requirements it has not been practicable to adopt standard types of construction. Types ranging from graded earth to the highest types of surface are approved, the principal requirement being that the type selected shall be adequate for the conditions to be met.

The Federal-aid system which includes the main interstate and intra-state routes of the Nation consists of 169,857 miles and on June 30, 1929, 78,096 miles had been completed with Federal aid. Work has been done on the system without Federal aid and it is estimated that it is now 90 per cent initially improved. However, there still remains a large amount of work in addition to the unimproved sections as much of the present improvement needs to be improved to higher degree to make it adequate for traffic requirements.

The bureau also has charge of the construction of roads in the national forests with funds which have been provided by Congress. The forest highway system includes 14,165 miles of road which are intended to make the national forests accessible to tourists, develop their natural resources, furnish fire protection, and afford connecting links on the through highway

routes. On June 30, 1929, 4,090 miles of such highways had been completed.

Closely allied with its work in the national forests is the work, which it is carrying on under agreement with the National Park Service of the Department of Interior, as the engineering agency of that Service in the survey and construction of the important highways of the great national playgrounds and monuments.

Highway Research.

The habits of study formed by the early organization when study was the principal duty have been continued in the later years since the larger work has been the administration of the Federal-aid program.

But, whereas in the earlier years the bureau's studies were undertaken only that it might be fitted to teach others how to build and maintain roads and how to administer and finance them, now that it has become a road builder itself on a large scale, its studies, suggested usually by the problems it encounters in its constructive work, are undertaken primarily with a view to determining its own administrative policies.

Yet the fact that it is cooperating in its work of road building with every State highway department, and that its problems are the common problems of all these agencies, gives to its researches perhaps a more direct practical significance and effect than they had when its role was that of the teacher only.

The highway researches of the bureau are of three general classes, each class the function of a separate division of the organization.

Physical problems involving the characteristics of road materials and their behavior in the road, separately and in combination, and problems associated with the forces of traffic and climate which affect the road structure and the design of the structure to resist their destructive action, are investigated by the Division of Tests.

The Division of Highway Transport studies the road as a transportation facility and deals with all problems of finance and economics that bear upon the cost of roads to the public and the return to users and general public in the form of reduced vehicular operating costs.

The economic problems involved in the construction of the roads themselves and their maintenance; those problems which have to do with the efficiency of construction processes and the output of construction plants and forces in relation to the expenditure of time, money, and effort are the concern of the Division of Management.

In carrying out its investigations, the bureau makes use of both intensive laboratory analyses and tests and extensive experiments and observations, the latter involving large sections of specially constructed test roads, actual roads in all parts of the country, and entire road systems of States and counties.

In addition to its laboratories for routine testing at the headquarters office in Washington, it maintains other laboratories for experimental purposes at the Experimental Farm of the Department of Agriculture at Arlington, Va. At the latter location it also has a large outdoor testing ground where road surfaces of various kinds are tested under controlled traffic, where the effects of climatic and vehicular forces are investigated, and where much of the important work of subgrade soil investigation is carried on.

Methods of Investigation Illustrated.

The latter studies will serve to illustrate the general method of investigation. Realizing the economies that would result if, in the construction of roads, the engineers were possessed of a more exact knowledge of the probable behavior of the wide range of natural soils upon which the surfaces and pavements are laid, the bureau has determined to supply its own engineers and others, if possible, with such knowledge.

In the pursuit of this object it first makes careful studies in all parts of the United States of the conditions surrounding road failures to which it is suspected that an adverse subgrade condition has contributed. In each case the conditions of climate, location, and drainage are carefully investigated, and samples of the subgrade soil are taken for analysis.

Meanwhile, at Arlington, work is in progress looking to the development of simple tests which may be applied to different soils for the purpose of identifying their characteristics and probable behavior under various climatic conditions. This work also includes a study of the effects of the various elementary soil constituents upon the behavior of composite soils in which they are present in varying amounts.

When the samples of subgrade soil taken in the investigations of road failures are received at the laboratory, they are subjected to the tests that have been devised, and the results are studied in relation to the known conditions of the soil in the road in an effort to determine the exact cause of failure.

As, steadily, bit by bit, knowledge is acquired of the habits and native character of soil, there is also an increase of knowledge in regard to those things that may be done to correct unfavorable soils or to alter the surrounding conditions in such ways as to prevent the recurrence of failures similar to those that have been observed.

The other investigations of the bureau are similarly inspired, and in a similar manner prosecuted. The problems investigated are those that are intimate to road construction. In large measure the work is conducted out-of-doors on actual roads or large experimental sections. The aspects of physical and economic phenomena studied are studied by no other government agency, and the bureau studiously avoids any work which can be more advantageously done by such other agencies.

Agricultural Engineering.

The work of the Division of Agricultural Engineering consists chiefly in conducting research directed toward solving the engineering problems of agriculture and in making available to the public, through appropriate department publications, the results of the studies. The work is done chiefly in cooperation with other bureaus and with State agricultural experiment stations. In addition to research work, considerable service of a consulting nature is rendered to the bureaus of the department in connection with their problems that involve engineering. Five distinct classes of work are dealt with in the activities of the Division of Agricultural Engineering, namely, irrigation, drainage, mechanical farm equipment, farm structures and appurtenances, and farm-land development.

Irrigation Investigations

Work in irrigation includes chiefly studies of the measurement, distribution and utilization of water for irrigation and the organization, operation, and maintenance of irrigation districts. The investigations are directed chiefly toward securing the best possible use of the limited water supply available for irrigation in the arid West. They deal with the water requirements of plants, the conserving of off-season rainfall, the best methods of bringing water to the plants, and the prevention of losses of water. They include also development of the best types of apparatus for measuring irrigation water, and determination of the characteristics of flow in irrigation conduits

and of the best methods of maintaining the latter. Certain engineering-economic studies are being conducted in the effort to develop the best procedure for irrigation organization. Related to the subject of applying water to the soil is that of affording the drainage that becomes necessary as a result of irrigation to prevent water-logging of the land and to reclaim areas already damaged by surplus water. Some studies are also under way in connection with irrigation as practiced in the humid areas of eastern United States, particularly as regards the use of municipal and institutional sewage for irrigation.

Drainage Investigations.

The primary purpose of the drainage investigations is to develop fundamental facts which when applied tend to result in more effective and more economical practice in the draining of agricultural land and in preventing and correcting the disastrous action of soil erosion. The quantity of water (run-off) that must be provided for by drains in order to accomplish satisfactory drainage is one of the important lines of research. Other lines of inquiry deal with methods and equipment for securing drainage by pumping, the effects of soil acids and alkalies on drain tile, the laws governing the flow of water in various types of drainage channels under different conditions, the drainage characteristics of soils, and the prevention of soil erosion and reclaiming of eroded lands to agriculture. The erosion studies are conducted under a special fund and in cooperation with the Bureau of Chemistry and Soils and certain

State agencies. They have for their object the prevention of the tremendous losses of top soil now taking place on the agricultural lands of the United States in the form of surface erosion and gulleying.

Mechanical Farm Equipment Investigations.

In this field studies are under way which have for their object the improving of existing farm machinery and the developing of new machinery to meet specific needs. Chief among these studies are those relating to the control of the European corn borer by mechanical means. It is now well recognized that proper equipment and tillage operations afford the most practical means of corn borer control. Special equipment or new attachments to existing equipment are necessary, however, as well as certain changes in the operations program of the farmer in the borer-infested areas. Effort is being made to anticipate the spread of the borer into new areas by the development of such equipment as will enable the farmer to meet his problem. Another class of project under way is typified by investigations being conducted with the object of improving the distribution of fertilizers, having in mind especially the requirements of specific crops. At the present time such study with reference to cotton is in progress in cooperation with the Bureau of Chemistry and Soils and certain outside agencies. The care and use of the combined harvester-thresher has been the subject of study for several years in cooperation with other bureaus of the Department, and State agencies. The development of equipment for the drying of seed cotton has been under

investigation for several years and equipment has been worked out which it is believed is entirely practicable. An exhaustive experimental study of the equipment and processes employed in ginning cotton has been started which promises to lead to very important results from the standpoint of the cotton grower and processer.

Farm Structures

The field of farm structures includes not only the farm home and the appurtenant items of heating, lighting, sewerage and water supply but also other structures of the farmstead such as barns, poultry houses, hog houses, as well as the minor structural items and the matters of ventilation and temperature control. The storage of grain on the farm, the structural requirements of fruit and vegetable storages, and the facilities for transporting perishable products are all important lines of research now engaging the attention of the Division of Agricultural Engineering. There is under way a project involving study of the whole subject of research in farm structures, the hope being to develop a program of research in this field that will affect not only the work of the Division of Agricultural Engineering but that of the State agricultural experiment stations.

Farm Land Development.

One of the obstacles to the effective use of modern machinery in American agriculture is the fact that in some sections fields are small, irregularly shaped, and frequently contain obstructions such

as stumps and stones, unnecessary hedge rows and fences, and ditches. This applies particularly to the South and to some extent also to the Northeastern States. The most practicable methods of rearranging the fields to secure suitable tillage units from the standpoint of machinery, is a subject of study that affords large opportunity for benefit to agriculture.