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HUTCHINSON RIVER PARKWAY IN THE PARK SYSTEM OF WESTCHESTER COUNTY, NEW YORK

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PARKWAY FEATURES OF INTEREST TO THE HIGHWAY ENGINEER

Reported by E. W. JAMES, Chief, Division of Design, United States Bureau of Public Roads

CONDITIONS responsible for the conception of the superhighway have led also to the use of the parkway to make possible the rapid movement of lightweight vehicular traffic through congested areas. Such developments have usually been in metropolitan and suburban areas; but the inherent possibilities of the parkway are so great that the Bureau of Public Roads considered it desirable to make an examination of some of the more important constructions within convenient distances of Washington with a view to analyzing the features that are of special interest to the engineer.

The parkway can serve a twofold purpose when adequately handled: It may be made to provide at the same time a park, in its proper sense, and an arterial highway. The two objectives, however, conflict to some degree and an even balance must be struck to secure the most satisfactory results. Vistas are generally short, especially in lateral directions, and landscaping as a park feature must be done accordingly. This requires taking advantage of many small details that might be developed in a bolder manner in ample park areas. The highway itself must be considered constantly in order that the capacity of the parkway as a means of traffic relief may be maintained.

Separation of Highway Grades in the Bronx River Parkway

OUTSTANDING PARKWAY FEATURES SUMMARIZED

These observations are the result of inspections of several parks and parkways, where it was possible to see, completed and in operation, parkway features and designs that are entirely satisfactory from both an artistic and technical viewpoint, and also to see others, likewise completed, that demonstrate the disadvantages of certain details.

Undoubtedly the outstanding parkway developments are in the New York metropolitan district, where Palisade Interstate Park, Bear Mountain Park, the Bronx Parkway, and the Westchester County park system furnish a variety of detail nowhere else available in the Eastern States. The condition of improvement of the Bronx Parkway, New York City, and the Westchester County park system make these two areas of peculiar interest, and they may well be considered together as they are contiguous in location, largely identical in conception and purpose, continuing to a large extent in administration, and identified by similar influences on design and success in execution.

From the first contacts the wisdom of the design and the satisfying quality of the work are apparent and impressive. This feeling is intensified when opportunity is found to observe, as later it was by the writer in Boston and vicinity, other parkways destined to the same general purpose, planned along the same generous and widespread layout, and detailed in such a manner as to be adequate for service but quite undistinctive as parkways.

The principal incentive to development of the big system of parks and parkways in Westchester and the Bronx, apart from the relatively minor impulse due to the need of renovating the lower reaches of the Bronx River in upper New York City, as the city extended beyond the Harlem River, was the need for additional traffic arteries leading out from the New York metropolitan area into the only contiguous mainland available for suburban development. The intensity of this incentive may be somewhat measured by the alternatives of using bridges or tunnels on the East and Hudson

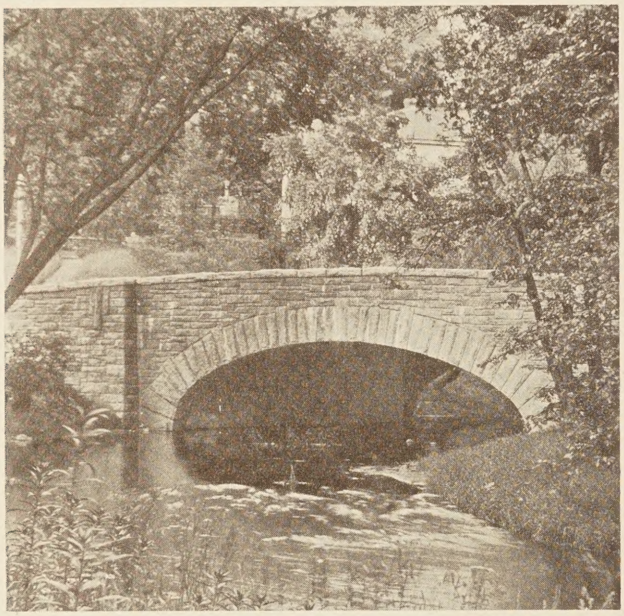
Rivers, or the inherently inadequate ferries across a normally more or less crowded harbor.

The fact that essentially the Bronx and Westchester Parkways were conceived and have so far been executed as relief highways to a great metropolitan area is notable. The cleaning up following the completion of the great Bronx River Valley trunk sewer opened the way to elevating such needed highways into parkways, and the success with which the idea has been carried out is an example for all such work.

The completed part of the system, although but a quarter of the whole proposed system, is large enough and old enough to furnish evidence of sound design.

Certain outstanding features may be conveniently and briefly summarized:

(*a*) The parkway is developed from the interior outward rather than from the margins inward. This is fundamentally important.



Bridges Over the Bronx River in the Bronx River Parkway

(*b*) Intersections at grade with other traffic lines of all kinds are eliminated.

(*c*) Access or approach roads, ramps, and border roads are brought into the parkway sparingly. The parkway is not intended to be just another local avenue or street.

(*d*) A single 40-foot pavement is considered and apparently is adequate for all traffic so far developed under the limitations of the parkway regulations.

(*e*) Two 20-foot pavements segregating traffic, with a parking between, are not adequate. Apparently two 30-foot pavements are needed to equal a single 40-foot pavement in capacity.

(*f*) Landscaping, finishing, planting, and opening to the public follow as rapidly as construction conditions permit. Completed sections are built from the rough in two seasons.

(*g*) All formal and studied landscaping is avoided. More local trees and shrubs, taken from the adjacent woods and reset, are used than nursery stock.

(*h*) Local stone is used in structures to a great extent, and unevenness of texture, color, and coursing, rather than evenness and regularity, are sought.

(*i*) Bridge and structure designs are rustic and unsymmetrical and made to fit the situation.

(*j*) The flat arch has been developed satisfactorily and attractively, and has been used in the solution of many difficult grade separation problems.

(*k*) Watercourses are cleaned, cleared, and controlled by judicious dredging and filling and by the use of small, inexpensive weirs.

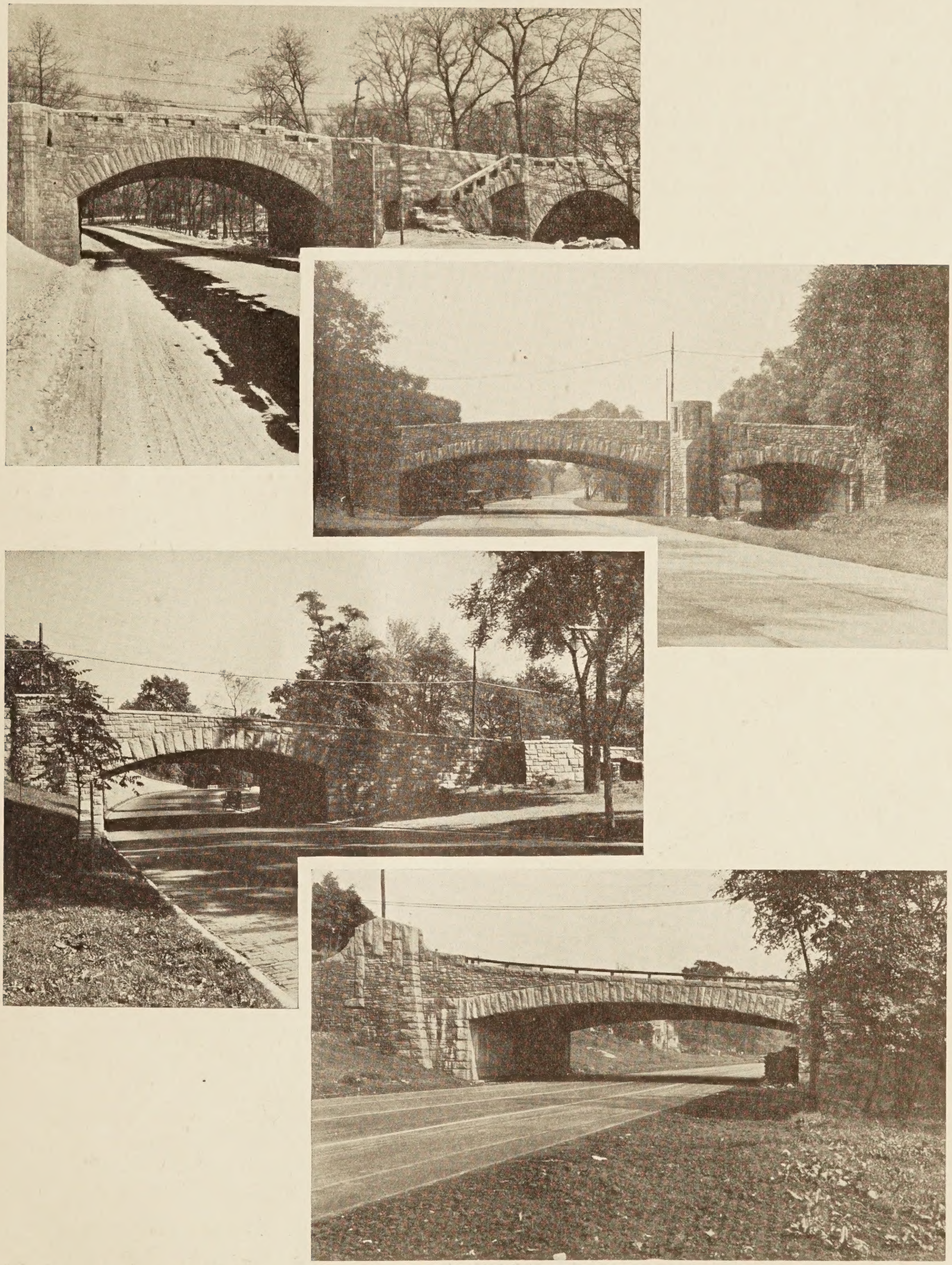
(*l*) Tangents are avoided in the pavement layouts.

(*m*) Deep cuts are avoided and grades follow the surface. Earth necessary for fills is obtained by widening cuts and flattening slopes in cut. To reduce fills curvature is introduced.

PARKWAYS SHOULD BE LOCATED IN INTERIOR OF PARKS

By placing the highway development in the interior of the parkway area and working outward, all possible freedom in details of location is secured, and what is of most importance, there is available on both sides of the roadway ample space for landscape development necessary to screen and hide any objectionable or unsightly features adjacent to the parkway. Such screening is essential along a parkway laid out through city suburbs, along railroads, and through small towns that invariably have purlieus that are unattractive. In addition, the interior development of the parkway encourages its separation from the rest of the highway and street net in the vicinity. The relative advantages of the two general methods of interior and marginal development, respectively, are seen by comparing the Bronx and Westchester developments with the metropolitan park system around Boston where the marginal system of designing prevails.

The metropolitan park system is comparable in size, conception, and purpose with the Bronx and Westchester systems. Starting with a sanitary clean-up of the lower reaches of the Fenway, a sluggish marsh estuary, outlet of a small brook from Jamaica Pond, the system has spread to include an area comparable with Westchester County. The marginal scheme of development has been unfortunately used to a large



Flat Arch Bridges Used for Separation of Highway Grades, Westchester County, N. Y.

extent, with the disadvantages that are associated with it. As a result, the drives become the frontage streets for miles of private property. A large number of private driveways debouch directly into the park drives; for miles there is only a nominal distinction between the parkway and an ordinary avenue. There are numerous points where it has been impossible to screen from view objectionable property abutting the parkways.

On the other hand, in the Bronx and Westchester systems there is room for screening, and with the exception of a few hundred feet at one point the park driveway never serves as a frontage street to private property. Also, the distance from the right-of-way lines where interior development is used facilitates the separation of intersecting routes.

HIGHWAY INTERSECTIONS AT GRADE OBJECTIONABLE

The original policy of the Westchester County Park Commission with regard to intersecting routes has been greatly strengthened. At first they eliminated only the most dangerous grade intersections. Those remaining became such obstacles to traffic that the commission has removed all such intersections. Their policy now is to leave no grade intersection whatever, but at all principal highway grade separations ramps between the two arteries furnish a connection. This is unquestionably sound and emphasizes the superhighway idea which was the strongest impulse toward the creation of the parkway system.

The disadvantage of unseparated highway intersections was noted definitely at many points in Fairmont Park, Philadelphia. Traffic police, automatic signal control, and objectionable intersections are there numerous. The inadequacy of the design of earlier days is apparent, and one is left with the conviction that there should be not the slightest hesitation to abandon the older ideas for new details that promise to serve better the demands of present traffic.

In the matter of access roads the arterial highway aspect is also fully recognized in the Westchester park system. Access to the parkway is provided at rather long intervals; by no means at every street intersection. In some instances the intervals are a mile or more in length. If abutting development requires it, a separate border road or street is constructed on which development faces, distinct entirely from the parkway and having access to the park drive only at long intervals.

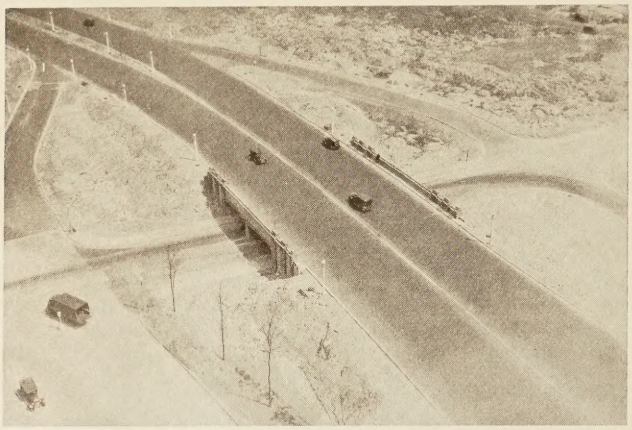
This condition is in marked contrast with the design and development of Roosevelt Boulevard northward from Philadelphia.

This boulevard clearly indicates what should be avoided in parkway design. To the city line the parkway consists of two 20-foot or two 30-foot pavements with a separating parked strip of approximately uniform cross section throughout. At the present time traffic uses the east-side pavement only for a considerable distance because of the bad condition of the west side

Airplane View of Roosevelt Boulevard, Philadelphia, Showing Frequent Street Intersections at Grade

Parkways Constructed by the Parks Division of the Metropolitan District Commission of Massachusetts. Upper—Woburn Parkway Near Woburn. Lower—Mystic Valley Parkway Near Medford

With the exception of a few important railroad grade-crossing eliminations, the entire boulevard is at the same grade as the streets of the subdivisions rapidly opening to the north of Broad Street, and the continued interruption to traffic promised by this design will in a few years ruin the parkway as an arterial route. It will become an elaborate city street and nothing more.



Separation of Highway Grades in Lincoln Park, Chicago

Estimates of the probable traffic capacity of a pavement should be modified where the layout affords relative freedom from direct intersections. With few access roads and grades separated at all main intersections, the observations stated under (*d*) are believed to be sound. With the four to five million people and 600,000 automobiles of New York City as a principal source of traffic, and with a highly developed suburban territory adjacent to much of the system, the Westchester commission finds the 40-foot drive generally adequate. Two 20-foot pavements, however, do not serve the peak traffic; and where the traffic lanes are separated by a parked strip, two 30-foot pavements are found to be the equivalent of a single 40-foot drive. In only a few sections, approaching resorts that are developed or to be developed, where traffic will be excessively concentrated, has the commission used or planned a 60-foot pavement.

DEFINITE PROVISION SHOULD BE MADE FOR PARKING VEHICLES

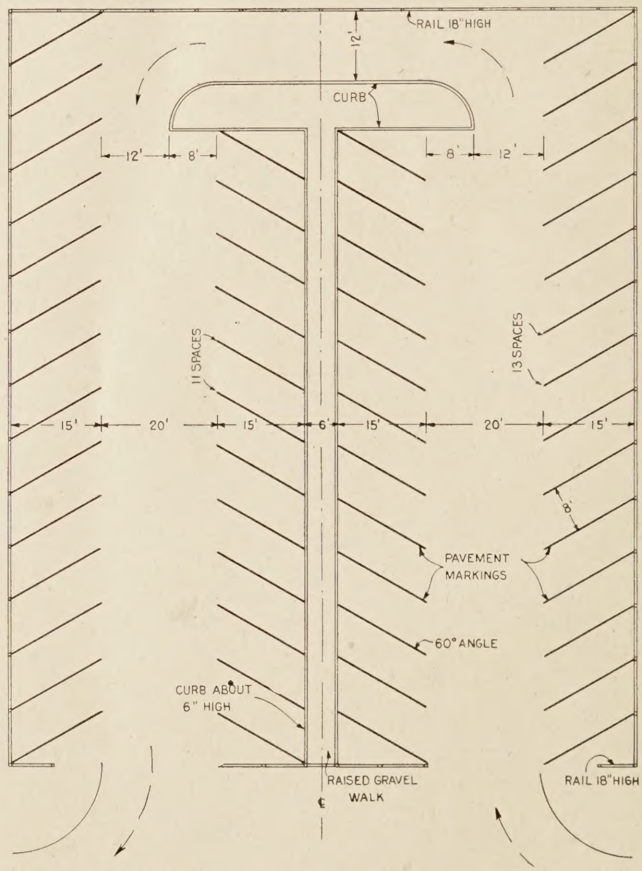
On Saturdays, Sundays, and holidays all parking of vehicles along the parkways, except at areas definitely provided, is absolutely prohibited and the regulation is enforced. Incidentally, luncheon parties are forbidden except at places provided. With these restrictions on vehicle parking during the days of peak traffic, the 40-foot pavement or the two 30-foot pavements adequately serve the traffic throughout most of the system.

Parking grounds for vehicles constitute a difficult problem for the parkway designer, because large areas, barren in appearance, add nothing of beauty to the parkway. Definite provision must be made for parking, however, if it is to be allowed. The design, layout, and construction of parking areas for motor vehicles in Valley Forge State Park, Pa., was observed as one of the distinctive features of this park.

The pathways which were noted between the parked vehicles added relatively little to the required parking area and furnished an element of safety and convenience. This feature would be particularly desirable in an expansion of the design to accommodate several hundred cars.

A sketch is shown of the smaller of the two areas seen, which gives the details and dimensions. Two such areas are located in Valley Forge Park, one to hold about 40 cars and the other about 90. Similarly, at Bear Mountain Park rather skillful use has been made of limited areas for vehicle-parking purposes. No fair judgment could be reached regarding the effect of parking areas on the congestion at the west end of Bear Mountain Bridge. There is a heavy traffic which naturally seeks access to the various roads from the bridge, and also a maneuvering of vehicles to get into and out of the irregular and scattered parking areas. But the need of such areas is obvious, and they should be located and their layouts studied with great care to insure freedom of access and ease of entrance and exit.

The circuitous approaches to the Bear Mountain Bridge, compelled by the topography, are in all cases to be avoided where possible and especially when in juxtaposition with parking areas. Their disadvantage is obvious to one driving over them.



Layout of Area for Vehicle Parking in Valley Forge State Park, Pa.

LANDSCAPING AN IMPORTANT PROBLEM

The Westchester County Park Commission has found its work popularized and results expedited by landscaping and finishing the parkways with its own forces immediately after construction. In the heavy grading the slopes are not left with unsightly angles, but are flattened, so that the parkway forces can, with little additional work, ease them off naturally into the existing topography. Only in a few cases, where heavy fills have been unavoidable, is there any impression of outstanding or sharp construction lines. On the other hand, no effort is made to keep the slopes in a flat plane;

they are rounded, flattened, or worked into warped surfaces to match with the topography, maintaining only the general direction of slope required by drainage.

In the finishing, the local resources are used as much as possible. Trees, shrubs, wild flowers, and rock obtained from adjacent land in or without the parkways are used in appropriate ways. White birch trees, scattered through the woods, are taken up, reset, and grouped. Wild flower are bedded in groups, and even the common sumach was observed as an especially good material for low screening purposes.

Local stone has been used for structures in preference to a better quality but more uniformly colored stone from other places. The variegations of the local stone are much preferred to the flat tones of even colored granite from the New England quarries within reach. Both stones have been tried and the commission now uses granite of uniform color only for copes, quoins, and other occasional trim, in which it contrasts pleasantly with the uneven and more roughly dressed local stone.

Besides using a material natural to the landscape setting, the structural designs are made to fit each location. Bridge copes are not always symmetrical; where the situation requires it one side is raised higher by steps to meet the topography. Flat surfaces are broken with pilasters and counterforts; exposed abutment faces under flat arches are paneled in different colors. Flat, stepped, battlemented, and random cope is freely used, often in the same structure, and the effect is pleasing. The flat arch, used originally to provide clearance at the sides, has been developed satisfactorily, and is unquestionably less tunnellike than circular arches.

(Continued on p. 32)

A Footbridge and Spillway on Tibbits Brook, Westchester County, N. Y.

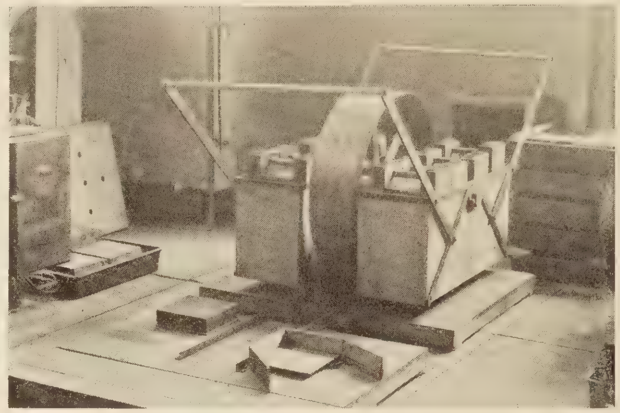
Reinforced Concrete Bridge, Bronx River Parkway, New York

A MACHINE FOR MOLDING LABORATORY SPECIMENS OF BITUMINOUS PAVING MIXTURES

Reported by J. T. PAULS, Senior Highway Engineer, Division of Tests, Bureau of Public Roads

THE STABILITY of a pavement and the resistance of its surface to raveling are important factors under present-day traffic. Present methods of designing asphalt paving mixtures are not certain of producing these qualities. If the aggregate always conformed closely in size and grading to the so-called "standard" a mixture could be designed on the basis of past experience with a reasonable assurance that it would have sufficient stability and cohesion. Unfortunately, the grading, size, and character of aggregate available on different jobs are variable and the designs adopted are often lacking in stability or resistance to raveling.

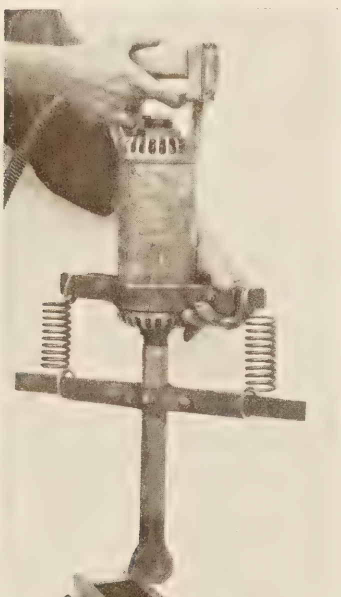
It should be an important function of a bituminous laboratory to determine in advance of construction the best possible combination of the available aggregates, filler, and asphalt. The work being done in various laboratories in developing apparatus and tests for determining the stability of asphalt paving mixtures is an important step in this direction.



An Early Molding Machine of the Roller Type which Proved Unsatisfactory Because of Lack of Uniformity in the Specimens

EARLY METHODS FOUND UNSATISFACTORY

In any laboratory test for stability the method of preparing the specimens is as important as the test itself. It should be such that uniform specimens of predetermined density can be prepared through a wide range of practical values. There should be no difference in the results secured by different operators.



An Electric Hammer Arranged for Molding Specimens 1¾" Wide

In recent years the bureau has been making field and laboratory studies of the stability of bituminous mixtures. In the earlier laboratory work various methods of molding specimens were used, the earliest being a weighted roller. This machine was unsatisfactory because of the lack of uniformity in the molded specimen and difficulty of duplication.

Until recently the electric hammer has been used as illustrated for compacting specimens.[1] Although used for some time, this method was not satisfactory, because of the difficulty in duplicating specimens and in compacting to a desired density and void content with reasonable accuracy. Molding by direct compression was unsatisfactory for the same reasons. It proved very difficult to compact large specimens to the density found in road surfaces. Crushing of the stone particles often occurred in compacting the coarse-aggregate mixes to the higher densities.

NEW MOLDING MACHINE DESCRIBED

The illustrations and Figure 1 show a molding machine developed by the bureau during the last year. It was designed primarily for molding specimens for test in the roller stability machine,[2] but the specimens are suitable for other types of stability tests. The machine has decided advantages over apparatus formerly used for this purpose. Specimens of different mixtures can be molded under the same pressure and to the same density obtained in actual paving. Another equally important advantage is that specimens of desired density and void content can be prepared. This makes it possible to determine the sufficiency of rolling on any asphalt paving project by comparing the density obtained in the construction with the maximum density obtainable on molded specimens using the same materials and proportions. The operation of the machine is entirely mechanical, thereby eliminating the personal equation of the operator.

The machine is designed to duplicate the compressing and kneading action of the roller actually used in construction. For this reason a heavy unit load, exceeding that used in construction, is not required and crushing of the aggregate does not occur.

The machine is very simple in design. It consists essentially of a loading arm with a rocker arm attached, a collapsible steel box for holding the specimen, and a driving mechanism by which the box is moved backward and forward. The loading arm is an I-beam 8 feet long, pivoted at one end and loaded with lead weights at the other. The load is transmitted to the specimen by means of a rocker suspended 18 inches from the fixed end of the beam. The rocker is a built-up section faced with a segmental circular shoe 4 inches wide and 8 inches in length, having a radius of 18 inches.

[1] A detailed description and the method of operation is given in Public Roads, vol. 6, No. 4, June, 1925.

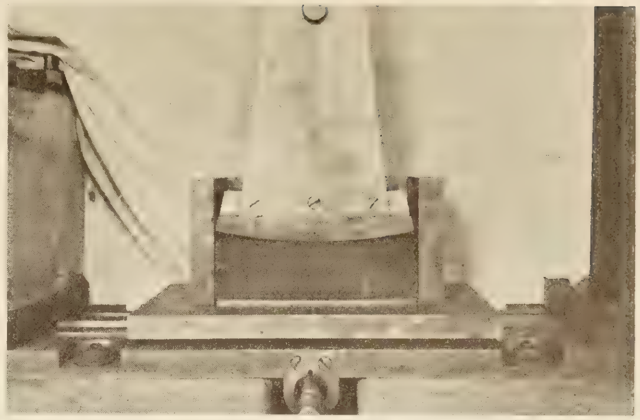
[2] This machine, which is described in Public Roads, vol. 7, No. 10, December, 1926, was recently rebuilt to eliminate certain objectionable features found in the design illustrated.

The collapsible box, in which the specimen is formed, is of 1-inch machined steel plates and rests on a heavy steel plate, which is supported on ball-bearing races. To the bottom of this plate is attached a rack and pinion, which provides for the backward and forward movement of the box containing the specimen. Operation is by means of a hand wheel.

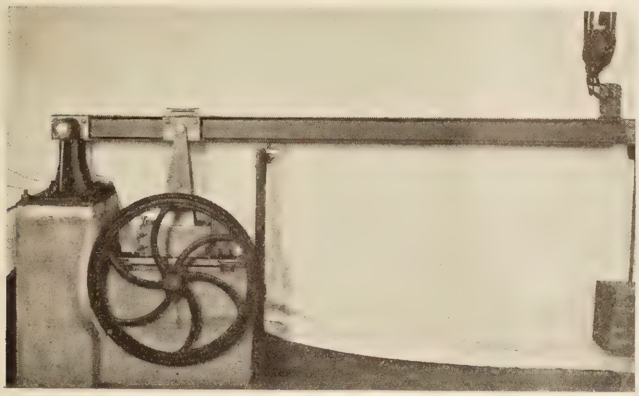
The vertical stop arrangement shown in contact with the arm is a rigidly fixed channel with an adjustable slow-motion screw at the top. This device not only regulates the thickness and density of the specimen but also insures parallelism of the top and bottom faces.

NEW MACHINE IS SIMPLE IN OPERATION

In molding a specimen, the necessary quantity of the mix (method of determination explained later) is heated to the proper temperature and placed loosely and evenly in the mold. A steel plate is placed on top of the uncompacted material to prevent its being squeezed upward at the ends during the initial compression. The rocker arm is lowered on the plate and the loading weights are applied at the end of the beam. The specimen is then rolled backward and forward for a period of about one minute. The plate is then removed and the rocker is again lowered. The process of rolling is continued until the stop, which has been set to give a specimen of the desired thickness, takes the load over the full length of travel, indicating that the desired compression has been obtained throughout and that the specimen is of uniform thickness. The time required to mold a specimen averages about five minutes



Side of Molding Box Removed to Show Molded Specimen



General View of New Machine

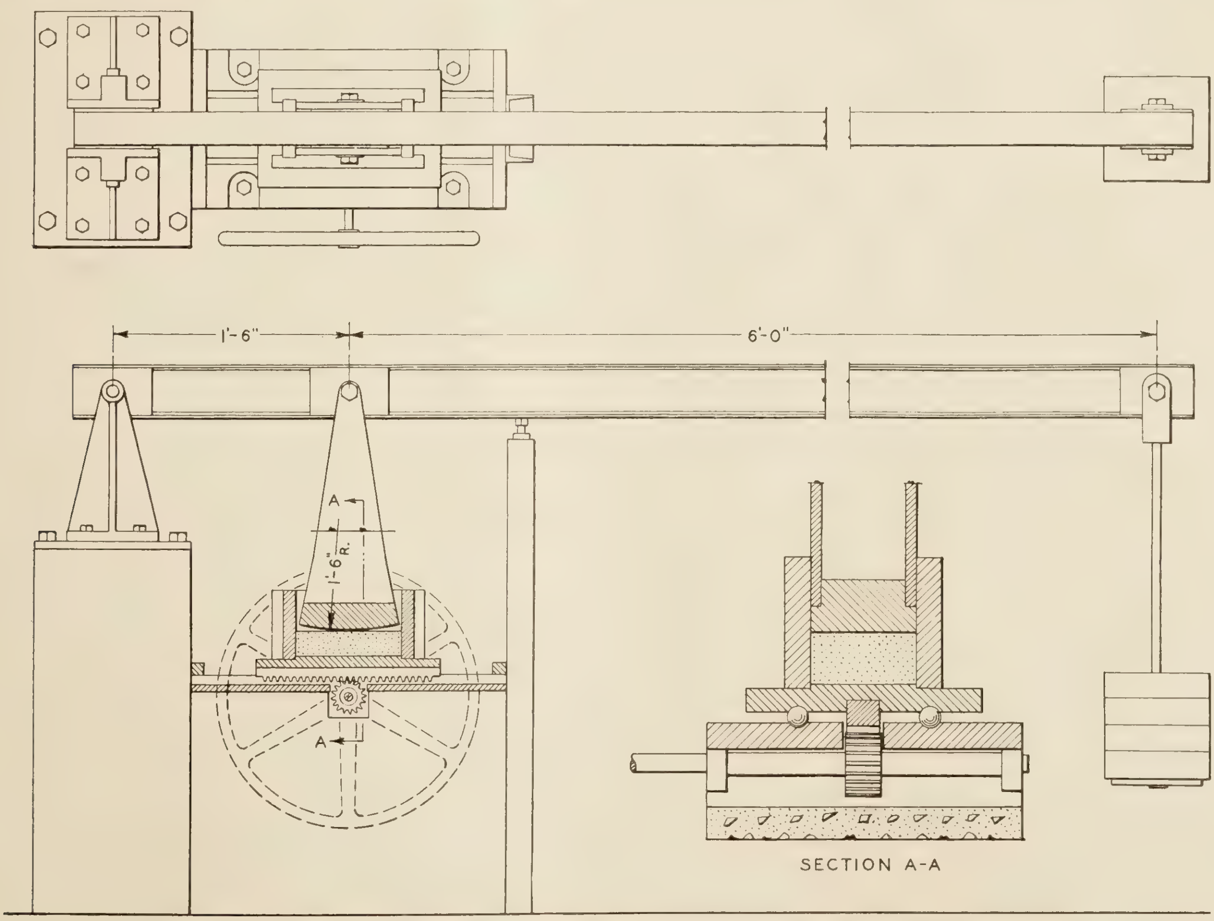


Figure 1.—Detailed Drawing of New Machine for Molding Asphalt Mixtures

but varies somewhat, depending upon the nature and character of the mix and the compression desired. Any desired load may be used with a corresponding time of operation. In the work done up to this time, a load of 375 pounds per inch width of specimen has been used. This conforms closely to actual construction conditions and, so far, has proved satisfactory.

In preparing the mix to be molded the specific gravities of the materials are determined in the usual manner. From these values the maximum theoretical density of the mix in grams per cubic centimeter is calculated from the following equations in which all percentages are by weight.

In molding specimens of mixtures other than sheet asphalt equally satisfactory results are obtained. Table 2 gives the results secured in molding a bituminous concrete mix composed of three-fourths to one-eighth inch stone, sand, filler, and asphalt. These results are characteristic of those obtained on coarse aggregate mixtures. The actual voids within the specimens (excluding surface voids) are slightly lower than those planned except on specimen No. 1. This is probably due to the slight honeycombing of the surface of the specimen at the ends and sides.

In weighing the material for each of these specimens no allowance was made for the decreased amount of material required because of the surface condition. Since the machine formed specimens of the correct dimensions the material which should have filled the surface voids caused greater density in other portions of the specimen. Closer check results could no doubt be obtained by reducing the quantity of mix for each specimen to allow approximately for the surface voids.

For sheet asphalt:

$$D_t=\frac{100}{\frac{\text{Percentage sand}}{\text{Sp. gr. sand}}+\frac{\text{Percentage filler}}{\text{Sp. gr. filler}}+\frac{\text{Percentage A. C.}}{\text{Sp. gr. A. C.}}} \qquad (1)$$

For bituminous concrete:

$$D_t=\frac{100}{\frac{\text{Percentage stone}}{\text{Sp. gr. stone}}+\frac{\text{Percentage sand}}{\text{Sp. gr. sand}}+\frac{\text{Percentage filler}}{\text{Sp. gr. filler}}+\frac{\text{Percentage A. C.}}{\text{Sp. gr. A. C.}}} \qquad (2)$$

Having determined the maximum theoretical density of the mix, the next step is to calculate the grams of mix necessary to make a molded specimen of a given height and void content. This is done as follows:

Weight of mix in grams required $=A\times D_t\times C$,

where A = the percentage of solid material in the specimen—i. e., 100 per cent minus percentage of voids—

D_t = the maximum theoretical density of the mix in grams per cubic centimeter,

C = volume of the molded specimen in cubic centimeters.

SPECIMENS PRODUCED OF SATISFACTORY UNIFORMITY AND OF DESIRED VOID CONTENT

Table 1 gives the actual void content obtained in molding specimens of a sheet asphalt, compared with the respective void contents desired. The results agree closely over the wide range of voids selected.

Table 1.—*Comparison between desired percentage of voids and actual voids obtained*

Sample No.	Desired voids	Actual voids obtained	Sample No.	Desired voids	Actual voids obtained
1	3.0	3.03	7a	7.0	7.18
2a	3.5	3.51	7b	7.0	7.18
2b	3.5	3.42	8a	8.0	7.98
3a	4.0	4.17	8b	8.0	8.13
3b	4.0	4.08	9a	9.0	9.05
3c	4.0	4.00	9b	9.0	9.02
4a	4.5	4.55	10a	10.0	10.14
4b	4.5	4.37	10b	10.0	9.98
5a	5.0	5.10	11a	11.0	10.90
5b	5.0	4.95	11b	11.0	10.65
6a	6.0	6.13	12a	12.0	12.26
6b	6.0	6.13	12b	12.0	12.32

Table 2.—*Comparison of desired percentage of voids and actual voids obtained for specimens of asphaltic concrete. The mix contained 40 per cent stone between the three-fourths and one-eighth-inch size*

Sample No.	Desired voids	Actual voids obtained	Sample No.	Desired voids	Actual voids obtained
1	3	3.29	4a	6	5.62
2a	4	3.78	4b	6	5.58
2b	4	3.82	5a	7	6.24
2c	4	3.91	5b	7	6.54
3a	5	4.79	6a	8	7.90
3b	5	4.61	6b	8	7.16
3c	5	4.61			

There is a fairly wide difference between the maximum theoretical density and the maximum practical density under field conditions, particularly for the coarse-aggregate type mixes. Aggregate which is either soft and fragile or which is placed in an improperly designed mixture will crush under the roller before the maximum theoretical density is obtained. It is sometimes desirable to know the maximum practical density of a mix of this type and it is believed that the molding machine can be used to make this determination. As shown in Table 2, the voids obtained in specimen No. 1 exceeded the amount planned, indicating that a void content of 3 per cent is impractical for the particular materials and proportions used. As it was easily possible to reduce the voids to all percentages from 4 up it appears that the minimum practical void content for this mixture is between 3 and 4 per cent.

A comparison of the results obtained in molding specimens 2 by 4 by 8 inches in size by each of the three methods described is given in Table 3. The mix in each case was identical, consisting of 10 per cent asphalt, 12 per cent dust, and 78 per cent sand by weight.

TABLE 3.—*Comparative densities and voids obtained in molding specimens by different methods, using the same mix and same size specimens throughout*

[Maximum theoretical density of the mix 2.308]

DIRECT COMPRESSION BY TESTING MACHINE

Pounds	Density	Voids
16,000	1.835	20.49
32,000	1.901	17.63
48,000	1.966	14.82
64,000	2.007	13.04
80,000	2.045	11.39
96,000	2.073	10.18
[1] 100,000	2.076	10.05

ELECTRIC HAMMER

Density	Voids
2.182	5.46
2.169	6.02
2.165	6.20
2.147	6.97

NEW MACHINE, USING LOAD OF APPROXIMATELY 375 POUNDS PER INCH OF WIDTH

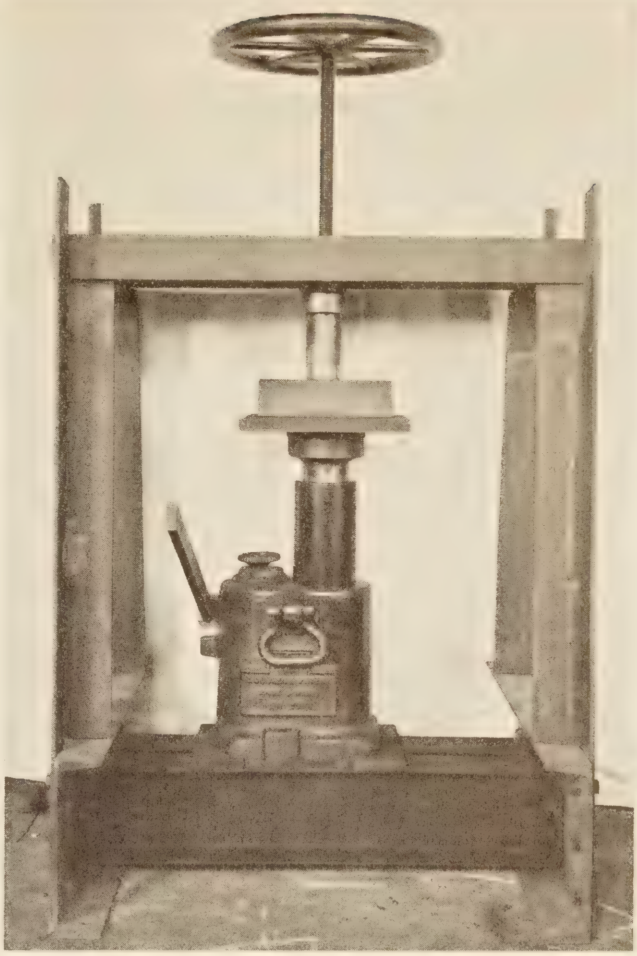
Density	Voids
2.218	3.90
2.217	3.94
2.216	3.99

[1] Limit of machine.

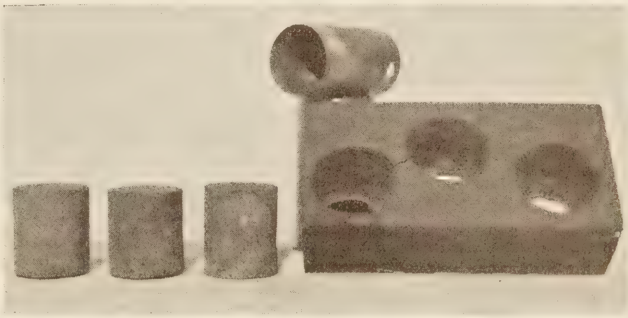
In molding under direct compression, using a universal testing machine, the total load varied from 16,000 to 100,000 pounds, equivalent to a unit load of 500 to 3,125 pounds per square inch. The voids obtained by this method ranged from 20.49 per cent for the light load to 10.05 per cent for the heaviest. These values greatly exceed those which are obtained in actual construction. With smaller specimens sufficiently low voids can be obtained by this method but where coarse aggregate is used, crushing often occurs particularly when using soft materials.

The results obtained with the electric hammer on a similar mix and for the same size of specimens show a variation in voids ranging from 5.46 to 6.97 per cent, which is about the minimum possible with this method and indicates the degree of uniformity obtainable by a single operator. In contrast to these results are those obtained with the new molding machine which check very closely.

Tests made on cores taken from newly laid sheet asphalt pavements in general showed higher voids in the top than in the bottom portion, while in the older pavements the reverse was found to be true. In the few cases studied, the specimens of sheet asphalt molded with the new molding machine had slightly higher density at the bottom than at the top (except at the corners), thus conforming with field experience. Table 4 shows the density at the lower corners to be materially lower than for the rest of the specimen. However, since the low density is confined to such a small portion of the specimen, which are tested in the same position in which they are molded, it will probably not greatly affect their value for test purposes.



PUNCHING CORES FROM SPECIMEN MOLDED IN NEW MACHINE

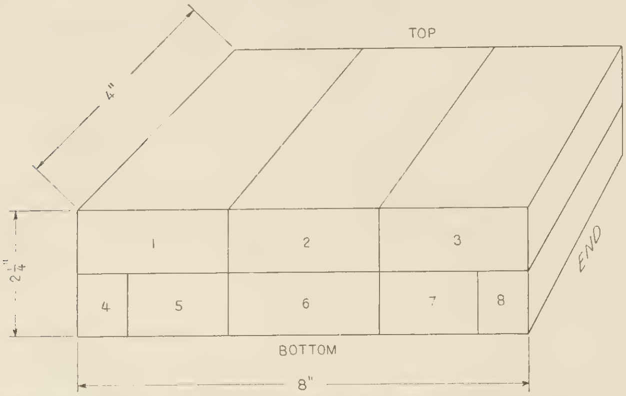


CORES PUNCHED FROM MOLDED SPECIMEN TO BE TESTED IN THE HUBBARD-FIELD MACHINE

MACHINE USEFUL FOR VARIOUS TESTS

The molding machine was developed primarily for preparing specimens of various types of paving mixtures for testing in the roller stability machine, but its use is not limited to that purpose. It has proved valuable in connection with the Hubbard-Field stability test on fine-grain mixtures. Three cores suitable for this test may be obtained from each of the molded specimens. The advantages of obtaining cores in this manner are that they are uniform in character and the density and voids can be controlled so that their effect and that of other factors may be readily studied. Illustrations show how cores for use in this test are taken from the molded specimens.

Table 4.—*Showing variation in density of specimens molded with the new machine, using a mixture having a maximum possible density of 2.338*



Specimen	Density of specimen[1]	Density of the portions							
		Top			Bottom				
		1	2	3	4	5	6	7	8
1	2.187	2.192	2.192	2.193	2.052	2.198	2.194	2.190	2.013
2	2.189	2.194	2.187	2.199	2.055	2.191	2.198	2.179	2.031
3	2.173	2.188	2.193	2.189			2.194		
4	2.193	2.186	2.187	2.195	2.019	2.178	2.207	2.180	2.015
5	2.200	2.241	2.221	2.212	2.218		2.240	2.192	

[1] No attempt was made to obtain maximum density.

In the design of types of surfacing, using bituminous materials applied cold, it is often desirable to make a preliminary study of the effect of such factors as character and quantities of bituminous material, grading, and size of aggregates, rate of hardening of the mix, etc. This can very often be done to advantage by molding specimens in the laboratory and observing their behavior.

It is not expected that this particular machine, as now designed, will prove adaptable to all the different types of stability test now used by different laboratories. However, it is believed that the principle of this machine is highly satisfactory and that with slight modifications its use can be widely extended and should prove a valuable adjunct to any bituminous laboratory.

INTERNATIONAL ASSOCIATION OF ROAD CONGRESSES ANNOUNCES ESSAY CONTEST

The following announcement is reprinted from the Bulletin of the Permanent International Association of Road Congresses:

The last triennial prize was awarded at the fourth congress, held at Seville, May, 1923. In accordance with the decisions taken, the 6th of September, 1926, and the 30th of June, 1928, by the Permanent International Commission, the next prize will be awarded during the sixth congress, which will be held in Washington in October, 1930.

This prize consists in the sum of 4,500 francs (approximately $175).

The conditions for entering this competition are as follows:

(*a*) The jury will award the prize to the author of the most remarkable study or essay submitted for encouraging construction progress, maintenance, and exploitation of the road and for facilitating traffic.

(*b*) It is obligatory that the authors be members of the Permanent Association of Road Congresses for at least six months and their inscription can not be subsequent to March 1, 1920. The members of the Permanent International Commission are disqualified from entering this competition.

(*c*) The essays must be in the hands of the general secretary of the association in Paris, 1, Avenue d'Iena, before April 1, 1930.

If the essays are written in any language other than German, English, or French, the original must be accompanied by a good translation in any of the aforesaid languages.

(*d*) The essays, handwritten or typewritten, must bear a date, must not be signed, but bear a mark without the author's name. The surname, proper name, attributes, and domicile must be placed in a sealed envelope, with the aforesaid mark plainly written on it, and the whole sent to the general secretary in a registered envelope.

(*e*) The essay winning the prize will be published by and at the expense of the association under the terms fixed in the first article of the regulations.

In case this essay has already been published, the author shall give the associations, gratuitously, the necessary authorization.

The amount of the prize will be paid to the winner only after this publication, and 25 copies in each of the languages admitted by the association for its publications shall be placed at the disposal of the author.

With regard to the nonwinning manuscripts, the association reserves the right to publish them, partially or in extenso, under the conditions fixed in the first article of the regulations.

(*f*) The result of the competition shall be proclaimed at the meeting held by the Permanent International Commission at the opening of the Sixth International Congress of the Road (1930).

(Continued from p. 27)

With all this departure from established engineering lines, always, of course, for the purpose of obtaining beautiful effects, the merely novel finds no satisfactory place. In two instances masonry bridges have been built with the outlines of suspension bridges, and these designs have resulted in nothing but deserved failure, admitted frankly by the commission's engineers as unfortunate mistakes.

The presence of a brook or small stream in a parkway is assuredly an asset from the point of beauty. By a very simple treatment of dredging, filling, and introducing small weirs, all shallows and marshy areas are at once eliminated, a clear demarcation set between water and dry land, and the stream lines are varied by broadening and contracting the channel.

A distinctive and very pleasing feature of Forest Park, Springfield, Mass., is the development of basins and the use of aquatic plants as well as land plants for pleasing effects. Even the common cat-tail, as well as delicate Egyptian and Phœnician lotus, is there used effectively.

The final points, (*l*) and (*m*), relating to tangents, curvature, and grading are important in their application to parkway construction. The constant rather sharp curvature in some places in Westchester is undesirable as observed, and the introduction of curvature is carried to extremes, certainly at some points. It has been done, doubtless, in the interests of landscaping. On the other hand, it requires no expert qualities to determine that long, unbroken tangents are ugly and undesirable except on an intended speedway. They are to be avoided rather than sought, and where used should be relieved by some vistas that convert them into attractions.

The widening of cuts excessively to get earth, instead of deepening them and of reducing fills by curvature, has the general effect of leaving the land largely unmarred and enables the landscape forces to disguise and conceal construction lines. Reducing the gradient of side slopes to angles below that of repose largely prevents slipping, washing, and weathering, and planting and growth of vegetation are facilitated.

SOME ASPECTS OF FLOW OF WATER AROUND BENDS AND BRIDGE PIERS [1]

By D. L. YARNELL, Senior Drainage Engineer, Bureau of Public Roads, U. S. Department of Agriculture

HYDRAULIC RESEARCHES on the flow of water around bends have been conducted for the last three years at the hydraulic laboratory of the University of Iowa by the university in cooperation with the Bureau of Public Roads. The investigation was undertaken to determine the laws governing the changes in pressure and velocity in different parts of a flowing stream as the moving water undergoes the transition from motion along a straight line to motion around a bend, and again as it undergoes the opposite transition back to a straight-line motion. This condition of transitional flow exists whenever water flows in a crooked channel or whenever moving water meets a bridge pier or any other form of obstruction.

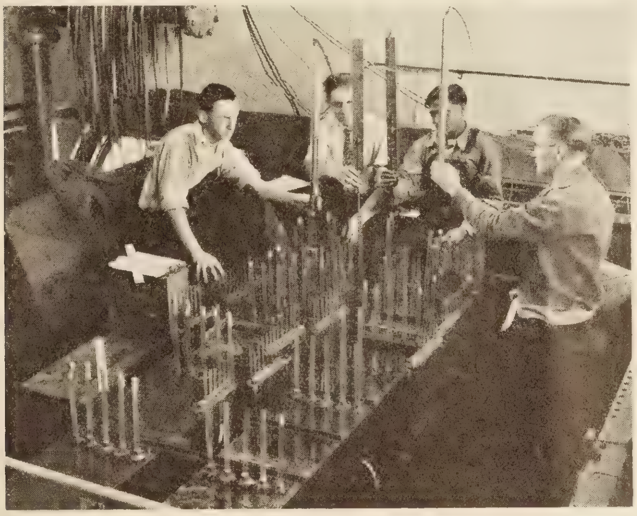


Figure 1.—Determining Velocity Distribution with Pitot Tubes

The apparatus for the tests consisted of a tank 5 by 5 feet in horizontal cross section and 8 feet deep, an approach channel 26 feet long leading from the tank to the bend, a 180° bend with a 5-inch inner radius, and a discharge channel 30 feet long. The bend and the two channels were 10 inches square.

The bend and 8 feet of each of the approach and discharge tangents next to the bend were made of transparent material so that studies might be made of the direction of flow of various particles of water in moving around the bend. A small steel frame, 10 inches square, was built and lined with transparent pyralin, or celluloid. Some 300 piezometric connections were made in the apparatus so as to study the changes in pressure as the water flows around the bend. A comparison of velocities at various points was essential to the investigation, and special Pitot tubes, made and calibrated in the laboratory, were used in the tests.

A view of the bend showing the men taking velocity measurement, and also showing part of the 300 piezometer connections, is given in Figure 1.

[1] Paper presented before the Federation of Engineering Societies of Minnesota on Feb. 22.

Tests were made with the channel flowing full under some pressure and also partly full. The experiments included studies with uniform velocity distribution, and also with nonuniform-velocity distribution in the channel approaching the bend.

A complete experiment for one quantity of flow required the measurement of pressures at 300 different points, the recording of velocities at 700 different points in the two tangents and the bend, as well as studies on the direction of flow. Approximately 45 man-hours were required to collect the necessary data for one experiment.

TESTS SHOW SPIRAL MOTION OF WATER AT BENDS

This paper discusses only one phase of the investigation—the direction of flow of the various particles of water in moving around a bend.

Let us consider the case when there is uniform velocity distribution in the channel approaching the bend. When such a condition occurs the water in the bottom part of the bend will rotate counterclockwise, while the water in the top part of the bend will rotate clockwise, as shown in Figure 2. Assuming such a condition of flow exists, if several yarns attached to a pin are placed in the channel next to the outside wall the yarns should diverge, whereas if placed next to the inside wall they should converge. That such a condition prevails is illustrated in Figure 3, which is composed of 11 separate pictures taken of yarns attached to pins and placed at various distances from the outside wall of the channel.

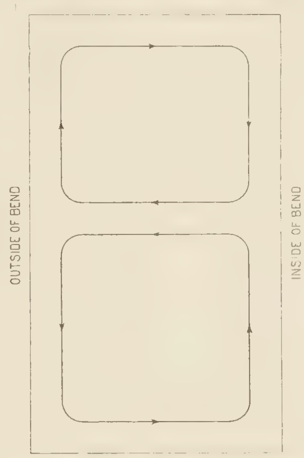


Figure 2.—Normal Condition of Spiral Flow Detected in Closed Channel Bend. Double Spiral in Channel

Where the friction along the bottom of the channel is greater than along the top the greatest velocity would be along the top and the lowest velocity along the bottom of the channel. With this velocity distribution in the channel approaching the bend, the water takes a single spiral or helical motion in addition to its forward motion in flowing around the bend. This spiral motion is counterclockwise as shown in Figure 4. Thus the yarns next to the outside wall will deflect downward, whereas those next to the inside wall will tip upward. This is illustrated in Figures 5 and 6.

The spiral motion shown in Figures 5 and 6 exists at the bends of rivers and is the cause of the erosion along the outer bank. The downward motion of the water rolls the particles of soil to the bottom of the channel, from whence they are carried diagonally toward the inner bank. The highest velocity of water is not along

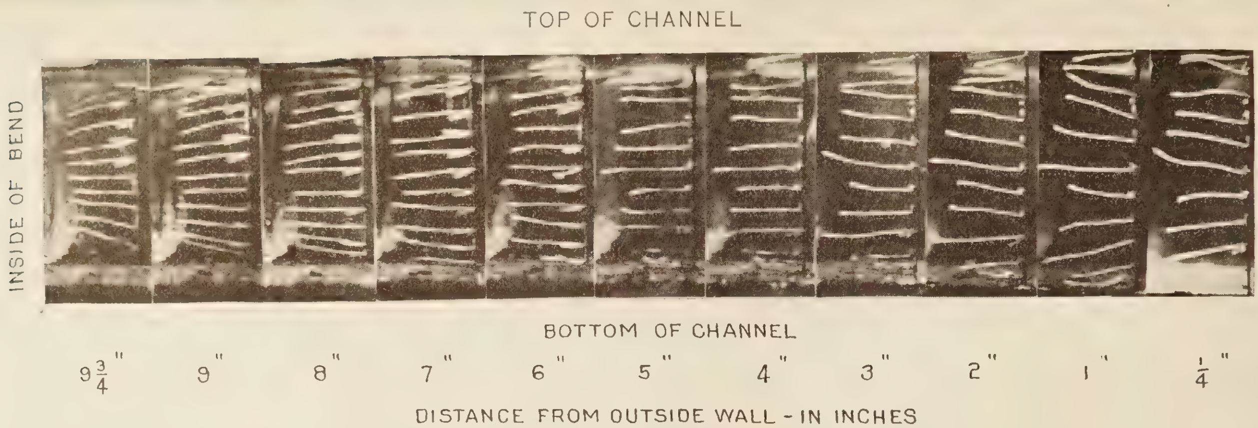


FIGURE 3.—DETERMINING SPIRAL FLOW BY MEANS OF YARNS IN 180° CLOSED CHANNEL BEND WITH 5-INCH INNER RADIUS. CHANNEL 10 INCHES SQUARE. VIEW IS COMPOSED OF 11 SEPARATE PICTURES TAKEN OF YARNS ATTACHED TO WIRES AND PLACED AT VARIOUS DISTANCES FROM OUTSIDE WALL

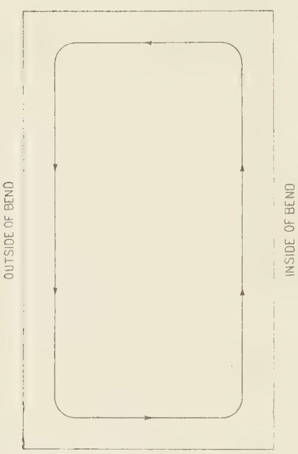


FIGURE 4.—NORMAL CONDITION OF SPIRAL FLOW IN BEND OF RIVER OR IN CLOSED CHANNEL BEND IN WHICH THE FRICTION IS GREATEST AT THE BOTTOM OF THE CHANNEL APPROACHING THE BEND

the outer bank, as commonly supposed, but is along the inner bank.

A practical demonstration of this spiral motion of water in flowing around a bend can easily be made. Take a glass of water and put in it two teaspoons of sugar. Then stir the water and notice how the sugar collects near the center at the bottom of the tumbler. This phenomenon is due to the unbalanced centrifugal force and spiral motion set up in the water. When the liquid is set in rotation by stirring, centrifugal force produces a greater hydrostatic pressure near the walls of the tumbler. But the liquid very close to the bottom surface of the tumbler, because of friction, can not rotate so fast, and thus the centrifugal force is not so great and hence does not counteract the radial hydrostatic pressure. The liquid in contact with the bottom of the tumbler is thus forced inward and carries the sugar with it.

It is believed that the erosion at bridge pier noses is due to a similar action. This spiral motion is greatest during flood stages. It is difficult to measure accurately the actual depth of the eroded section around pier noses, since the flood waters during their subsidence tend to silt up the pockets which were scoured out by the rising waters.

Tests were also made with various other conditions of velocity distribution in the approach channel to the bend and studies made of the spiral motion of the water in the bend. These researches are to be reported later.

There are several possible applications of this knowledge of the spiral motion of water in bends. It will be useful in the design of bridge substructures and stream-control structures. In pipe bends the spiral motion represents a loss of head, and where it is possible to straighten out the direction of flow of the filaments of water there should be an increase in efficiency. Quarter turn draft tubes are now designed with guide vanes in the bend, so as to make the water flow in a straight direction as well as to reduce eddy losses. In a large generating plant in Chicago a 90,000 kilowatt steam turbine has sharp 90° bends equipped with blade turns designed especially to reduce the spiral motion and consequent eddy losses.

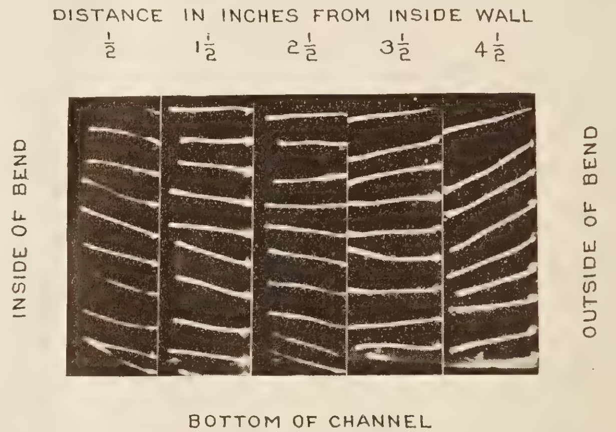


FIGURE 5.—DETERMINING SPIRAL FLOW BY MEANS OF YARNS IN 180° CLOSED CHANNEL BEND WITH 5-INCH INNER RADIUS. FRICTION IS GREATER AT THE BOTTOM THAN AT THE TOP. CHANNEL 5 INCHES WIDE BY 10 INCHES DEEP. VIEW IS COMPOSED OF FIVE SEPARATE PICTURES TAKEN OF YARNS ATTACHED TO WIRES AND PLACED AT VARIOUS DISTANCES FROM INSIDE WALL

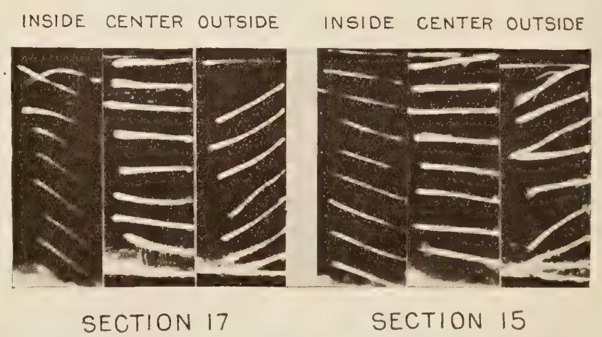


FIGURE 6.—DETERMINING SPIRAL FLOW BY MEANS OF YARNS IN 180° CLOSED CHANNEL BEND WITH 5-INCH INNER RADIUS. FRICTION IS GREATER AT THE BOTTOM THAN AT THE TOP. CHANNEL 5 INCHES WIDE BY 10 INCHES DEEP. SECTION 15 IS 45° AND SECTION 17, 135° FROM BEGINNING OF BEND. THE VIEW FOR EACH SECTION IS COMPOSED OF THREE SEPARATE PICTURES TAKEN OF YARNS ATTACHED TO WIRES NEAR OUTSIDE, MIDDLE, AND INSIDE OF CHANNEL

MOTOR-VEHICLE REGISTRATIONS, 1928 [1]

[Compiled from reports of State authorities]

State	Registered motor vehicles individually and commercially owned [2]			Other registered vehicles		Tax-exempt official motor cars and motor cycles			Number of licenses or permits		Registered motor cars and trucks, 1927	Year's change in motor-vehicle registrations		State
	Total registered motor cars and trucks	Passenger automobiles, taxis, and busses	Motor trucks and road tractors	Trailers [3]	Motor cycles	United States cars	State and local cars	Motor cycles (official)	Dealers	Operators and chauffeurs		Number increase or decrease (−)	Per cent	
Alabama	269, 519	235, 026	34, 493	1, 952	611	167	666		586	1, 097	243, 539	25, 980	10. 7	Alabama.
Arizona	94, 372	86, 036	8, 336	809	281	176	985		1, 039	12, 342	81, 047	13, 325	16. 4	Arizona.
Arkansas	214, 931	181, 280	33, 651	2, 054	342	39	851	27	508	4, 085	206, 568	8, 363	4. 0	Arkansas.
California	1, 799, 890	1, 582, 477	217, 413	37, 073	9, 449	1, 217	13, 526	149		263, 346	1, 693, 195	106, 695	6. 3	California.
Colorado	284, 867	260, 906	23, 961	85	1, 234	283			3, 547	7, 977	268, 492	16, 375	6. 1	Colorado.
Connecticut	309, 792	261, 091	48, 701	224	2, 497	71	1, 923	168	3, 751	337, 623	281, 521	28, 271	10. 0	Connecticut.
Delaware	51, 210	41, 195	10, 015	301	345	44			610	56, 923	47, 124	4, 068	8. 7	Delaware.
Florida	352, 961	296, 691	56, 270	[4] 1, 000	1, 127	75	3, 652	233	2, 047	2, 853	394, 734	−41, 773	−10. 6	Florida.
Georgia	318, 856	277, 881	40, 975	[5] 816	1, 078	934			1, 155	2, 301	300, 635	18, 221	6. 1	Georgia.
Idaho	108, 154	96, 960	11, 194	264	406	103	1, 231	18	458	395	101, 336	6, 818	6. 7	Idaho.
Illinois	1, 504, 359	[6] 1, 314, 003	[6] 190, 356	3, 742	5, 826	979			4, 548	94, 169	1, 438, 985	65, 374	4. 5	Illinois.
Indiana	823, 806	706, 713	117, 093	7, 884	3, 124	3, 184	4, 531		2, 716	39, 021	813, 637	10, 169	1. 2	Indiana.
Iowa	733, 466	672, 447	61, 019	230	1, 728	44	3, 200		2, 439	16, 563	704, 203	29, 263	4. 2	Iowa.
Kansas	533, 799	471, 897	61, 902	359	1, 199	192	2, 463	60	2, 676		501, 901	31, 898	6. 4	Kansas.
Kentucky	304, 231	272, 636	31, 595	[7]	742	90	1, 910	66	1, 138	9, 146	285, 621	18, 610	6. 5	Kentucky.
Louisiana	264, 293	223, 445	40, 848	4, 000	625	209			489	16, 029	255, 000	9, 293	3. 6	Louisiana.
Maine	172, 638	139, 460	33, 178	1, 068	1, 219	64	1, 326	75	1, 155	203, 353	163, 623	9, 015	5. 5	Maine.
Maryland	285, 311	275, 221	10, 090	683	2, 232	1, 969	1, 500		5, 853	76, 569	276, 863	8, 448	3. 1	Maryland.
Massachusetts	726, 295	637, 153	89, 142	547	6, 856	556			2, 370	870, 160	694, 107	32, 188	4. 6	Massachusetts.
Michigan	1, 249, 221	[6] 1, 084, 615	164, 606	23, 198	3, 686	371			2, 192	311, 413	1, 154, 773	94, 448	8. 2	Michigan.
Minnesota	673, 573	583, 789	89, 784	3, 894	2, 083	252	1, 153		2, 144		646, 682	26, 891	4. 2	Minnesota.
Mississippi	246, 242	214, 754	31, 488	2, 919	69	74			[4] 660		218, 043	28, 199	12. 9	Mississippi.
Missouri	712, 965	636, 717	76, 248	2, 004	1, 821	311	1, 472	3	2, 572	29, 222	682, 419	30, 546	4. 5	Missouri.
Montana	126, 035	104, 231	21, 804		185	229	1, 242		512	210	112, 735	13, 300	11. 8	Montana.
Nebraska	391, 355	358, 173	33, 182	2, 975	1, 026	226	1, 288		3, 344		373, 912	17, 443	4. 7	Nebraska.
Nevada	27, 376	21, 733	5, 643	178	94	42	442		115		25, 776	1, 600	6. 2	Nevada.
New Hampshire	102, 644	88, 594	14, 050	545	1, 330	22					96, 009	6, 635	6. 9	New Hampshire.
New Jersey	758, 430	629, 748	128, 682	1, 996	6, 633	708	6, 363	846	3, 176	1, 186, 736	712, 396	46, 034	6. 5	New Jersey.
New Mexico	65, 737	63, 743	1, 994	340	248	156	745	2	201		59, 291	6, 446	10. 9	New Mexico.
New York	2, 083, 942	1, 760, 549	323, 393	7, 148	14, 594	1, 666	14, 153	1, 208	4, 852	2, 494, 156	1, 937, 918	146, 024	7. 5	New York.
North Carolina	464, 376	418, 864	45, 512	1, 944	1, 244	429	6, 200		1, 103		430, 499	33, 877	7. 9	North Carolina.
North Dakota	173, 525	151, 778	21, 747		236	3					160, 701	12, 824	8. 1	North Dakota.
Ohio	1, 649, 699	1, 450, 994	198, 705	14, 606	9, 472	2, 362	10, 097		3, 967	4, 419	1, 570, 734	78, 965	5. 0	Ohio.
Oklahoma	529, 843	465, 550	64, 293		1, 124	530			1, 384		503, 126	26, 717	5. 3	Oklahoma.
Oregon	248, 118	227, 404	20, 714	1, 238	2, 012	141	1, 294	34	581	49, 250	244, 572	3, 546	1. 4	Oregon.
Pennsylvania	1, 642, 207	1, 420, 957	221, 250	4, 285	13, 807	1, 383	943		[4] 4, 300	1, 993, 455	1, 554, 915	87, 292	5. 6	Pennsylvania.
Rhode Island	125, 698	106, 155	19, 543	61	1, 071	56	685	95	318	144, 876	118, 014	7, 684	6. 5	Rhode Island.
South Carolina	216, 805	194, 267	22, 538	1, 637	432	91	2, 654		658		199, 635	17, 170	8. 6	South Carolina.
South Dakota	191, 374	171, 067	20, 307		230	85	945		1, 061		169, 552	21, 822	12. 9	South Dakota.
Tennessee	322, 137	294, 305	27, 832	[7]	1, 059	132	3, 289		693		294, 567	27, 570	9. 4	Tennessee.
Texas	1, 214, 297	1, 060, 028	154, 269	11, 955	3, 481	2, 505			3, 881	10, 178	1, 111, 407	102, 890	9. 3	Texas.
Utah	98, 541	84, 220	14, 321		520	173					93, 974	4, 567	4. 9	Utah.
Vermont	86, 231	78, 685	7, 546	218	521	28			376	89, 606	79, 527	6, 704	8. 4	Vermont.
Virginia	360, 545	306, 911	53, 634	646	2, 128	1, 141	3, 062	143	3, 524	7, 746	337, 607	22, 938	6. 8	Virginia.
Washington	402, 875	344, 977	57, 898	2, 279	2, 598	637	3, 981	139	4, 783	499, 149	384, 583	18, 292	4. 8	Washington.
West Virginia	251, 556	215, 787	35, 769	600	1, 355	33	2, 094	124	[4] 1, 088	73, 468	245, 819	5, 737	2. 3	West Virginia.
Wisconsin	742, 135	646, 747	95, 388	412	2, 746	92	1, 268	120			698, 289	43, 846	6. 3	Wisconsin.
Wyoming	56, 336	48, 760	7, 576		128	209	296		329		51, 955	4, 381	8. 4	Wyoming.
District of Columbia	126, 556	112, 505	14, 051		1, 092	837	2, 188	200	1, 835	34, 025	111, 680	14, 876	13. 3	District of Columbia.
Total	24, 493, 124	21, 379, 125	3, 113, 999	148, 169	117, 946	[8] 33, 179	103, 618	3, 710	[9] 86, 734	8, 941, 861	23, 133, 241	1, 359, 883	5. 9	Total.

[1] This table lists only the number of registrations, licenses, and permits. For financial statement see table on next page.

[2] The first 3 columns show regularly registered motor cars and trucks which pay regular license fees, eliminating reregistrations, nonresident registrations, etc. Busses are included with passenger cars except as noted.

[3] Some States include trailers with trucks; others do not register trailers.

[4] Estimated.

[5] Reported with tractors, but here separated as per semiannual report.

[6] Busses registered with trucks.

[7] Trailers registered as trucks.

[8] As reported by Bureau of Budget in 1925, and includes 7,859 "cars at large," not allocated to any State.

[9] Decrease compared to previous years due to eliminated dealers' plates formerly reported by some States.

MOTOR VEHICLE REGISTRATION FEES, LICENSES, PERMITS, FINES, ETC., 1928[1]

[Compiled from reports of State authorities]

State[2]	Total gross receipts	Registration receipts[2]					Miscellaneous receipts[2]			Disposition of gross receipts					State[2]
		Motor car receipts			Other vehicles						For highway purposes				
		Total from motor cars	Passenger cars and busses	Trucks and tractors	Trailers	Motorcycles	Dealers' license	Chauffeur and operator permits	Other miscellaneous	Collection and administration	State highways	Local roads	State and county road bonds	For other purposes	
Alabama[2]	$3,474,065									$151,721	$1,075,501	$677,443	$1,569,400		Alabama.[2]
Arizona	565,806	$433,846	$300,982	$132,864	$3,078	$967	$3,617	$12,608	$111,690		565,806				Arizona.
Arkansas	3,786,004	3,706,291			30,810	3,420	5,194	21,366	18,923	75,720	832,921	567,901	[3] 2,309,462		Arkansas.
California	9,292,301	7,857,528	5,174,678	2,682,850	269,318	34,332		330,475	800,648	1,426,542	3,910,311	3,910,311		[4] $45,137	California.
Colorado	1,790,183	1,658,931	1,331,484	327,447	2,504	2,231	28,350	15,871	82,296	166,313	811,935	811,935			Colorado.
Connecticut	7,373,589	5,627,215	4,222,116	1,405,099	462	11,792	83,274	1,041,649	609,197		7,373,589				Connecticut.
Delaware	928,916	745,256	540,046	205,210	4,641	1,463	6,855	169,279	1,422		928,916				Delaware.
Florida	4,935,995	4,873,611	3,611,324	1,262,287		5,384	26,684	5,390	24,926	521,968	3,201,150	1,165,449		[5] 47,428	Florida.
Georgia	4,041,767	3,975,763	3,320,729	655,034	9,357	5,151	37,682	4,457	9,357	143,088	3,898,679				Georgia.
Idaho	1,626,949	1,578,391	1,308,491	269,900	4,645	2,023	27,300	790	13,800		166,549	1,460,400			Idaho.
Illinois	15,521,530	14,578,770	11,177,192	3,401,578	65,678	19,274	88,166	331,292	438,350		9,337,237		6,149,016	[6] 35,277	Illinois.
Indiana	5,751,781	5,348,396	4,121,143	1,227,253	38,878	5,601	54,600	35,252	269,054	249,233	5,502,548				Indiana.
Iowa	10,692,767	10,133,702	9,092,308	1,041,394	4,068	5,864	81,188	33,125	434,820	203,982	10,068,490	367,712		[7] 52,583	Iowa.
Kansas	5,394,448	5,376,693							17,755	286,846	3,213,511	1,894,091			Kansas.
Kentucky	4,725,258	4,582,043	3,605,292	976,751		5,477	32,877	22,485	82,376	195,198	4,041,685	488,375			Kentucky.
Louisiana	4,383,634	4,303,207						80,145	282	(8)	4,383,634				Louisiana.
Maine	2,763,598	2,147,118	1,642,849	504,269	4,720	6,672	44,750	425,017	135,321	220,513	1,364,283		1,038,802	[9] 140,000	Maine.
Maryland	3,034,621	2,380,885	2,087,501	293,384	18,663	10,627	34,701	196,137	393,608	303,462	2,124,234			[10] 606,925	Maryland.
Massachusetts	13,919,618	11,127,853	7,854,817	3,273,036	24,127	29,564	69,185	1,740,320	928,569	1,352,012	11,643,077		924,529		Massachusetts.
Michigan	20,056,848	18,367,167	13,942,513	4,424,654	248,659	14,377	96,771	257,156	1,072,718	729,063	12,245,725	6,000,000	1,082,060		Michigan.
Minnesota	10,101,785	10,010,861	8,360,128	1,650,733	15,181	7,765	38,472		29,506		6,507,230		[11] 3,594,555		Minnesota.
Mississippi[2]	2,814,150									140,707	194,162	2,479,281			Mississippi.[2]
Missouri[2]	8,765,609									370,000	5,283,109		3,112,500		Missouri.[2]
Montana[2]	1,298,828									75,919		1,189,596		[12] 33,313	Montana.[2]
Nebraska	3,950,788	3,728,512	3,166,236	562,276	5,549	3,489	49,349		163,889	118,131	1,149,797	2,682,860			Nebraska.
Nevada[2]	249,111									11,485	109,790		127,836		Nevada.[2]
N w H hire	2,070,957	1,673,914				7,383	29,305	276,223	84,132	151,790	1,906,428			[13] 12,739	New Hampshire.
New Jersey	13,569,029	9,933,564	6,164,890	3,768,674	71,778	13,266	79,210	2,797,372	673,839	849,699	7,882,354	4,536,976		[14] 300,000	New Jersey.
New Mexico	627,751	598,781	530,407	68,374	4,066	525	10,700		13,679	70,406	371,633	185,712			New Mexico.
New York	34,306,706	31,084,438	22,301,399	8,783,039	130,341	63,651	204,728	2,819,842	3,706	1,785,572	23,999,877	5,196,770		[15] 3,324,487	New York.
North Carolina[2]	6,088,140									300,000	3,975,334		1,812,806		North Carolina.[2]
North Dakota	1,775,145	1,760,006	1,431,339	328,667		1,285	13,380		474	170,000	[16] 867,573	737,572			North Dakota.
Ohio	11,840,258	11,265,581	6,404,466	4,861,115	134,019	21,617	79,340	11,392	328,309	386,503	5,969,831	5,483,924			Ohio.
Oklahoma[2]	6,258,610										2,503,444	3,755,166			Oklahoma.[2]
Oregon	6,969,221	6,720,469	5,741,931	978,538		10,904	28,213	59,880	149,755	300,000	1,665,855	1,667,305	[17] 3,336,061		Oregon.
Pennsylvania	27,113,777	20,760,327	14,382,318	6,378,009	46,694	34,054	86,000	2,395,656	3,791,046	1,783,898	20,509,755		3,870,914	[18] 949,210	Pennsylvania.
Rhode Island	2,273,819	1,832,157	1,388,895	443,262	1,419	3,776	14,790	289,752	131,925	211,905	2,031,516	30,398			Rhode Island.
South Carolina	2,440,539	2,281,572	1,941,601	339,971	24,765	1,445	29,850		102,907	[19] 25,398	2,415,141				South Carolina.
South Dakota	2,901,905	2,872,391	2,480,721	391,670		1,073	26,540		1,901	59,901	1,450,002	1,392,002			South Dakota.
Tennessee[2]	4,066,478									109,014	3,957,464				Tennessee.[2]
Texas	17,701,251	16,960,630	14,117,670	2,842,960	162,482	13,804	60,025	30,203	474,107	500,519	10,011,767	7,188,965			Texas.
Utah[2]	731,340									130,000	343,370		257,970		Utah.[2]
Vermont	2,090,960	1,783,737	1,497,625	286,112		3,589	28,847	230,842	43,945	(20)	2,090,960				Vermont.
Virginia	5,572,046	5,168,554	4,342,248	826,306	5,913	7,497	67,276	35,654	287,152	260,000	5,312,046				Virginia.
Washington	7,028,291	6,368,405	4,957,338	1,411,067	50,120	13,639	85,903	502,281	7,943	285,454	4,201,591	2,038,965		[21] 502,281	Washington.
West Virginia	4,142,595	3,806,997	2,986,549	820,448	3,985	6,011	48,084	119,432	158,086	239,913	1,262,682		2,640,000		West Virginia.
Wisconsin	10,774,707	10,408,621	8,341,584	2,067,037	16,261	16,380		332,057	1,388	639,497	5,645,210	4,490,000			Wisconsin.
Wyoming	572,570	569,904	438,840	131,064		614	1,283		769		572,570				Wyoming.
District of Columbia	473,981	135,454	113,525	21,929		1,092	1,835	102,075	233,525	132,627				[22] 341,354	District of Columbia.
Detailed totals[2]	288,883,694	258,527,541			1,402,181	397,078	1,704,324	14,725,475	12,127,095						Detailed totals.[2]
Grand totals	322,630,025									15,133,999	208,880,272	60,399,109	31,825,911	6,390,734	Grand totals.

1 Financial data only on this table. For number of registrations, etc., see other table.
2 Several States do not report complete details and receipts are not included in detailed totals.
3 Includes $340,740 on State bonds and $1,968,722 on county bonds.
4 Revolving fund reserve.
5 Undistributed.
6 In State general fund.
7 Balance for refunds.
8 Appropriation $45,000 from State general fund.
9 For traffic police.
10 For Baltimore city streets.
11 On county bond obligations assumed by State.
12 Auto-theft fund.
13 Included in miscellaneous.
14 For State highway office building.
15 To New York City general fund.
16 Includes $130,000 for State bridge fund.
17 On State bonds, allotted from State highway fund.
18 Highway motor patrol.
19 Only expenses of law enforcement reported: Other expenses from highway fund.
20 Appropriated from State general fund.
21 State highway patrol.
22 For traffic control and streets, if so appropriated by Congress.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS

Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

ANNUAL REPORTS

Report of the Chief of the Bureau of Public Roads, 1924.
Report of the Chief of the Bureau of Public Roads, 1925.
Report of the Chief of the Bureau of Public Roads, 1927.
Report of the Chief of the Bureau of Public Roads, 1928.

DEPARTMENT BULLETINS

No. *136D. Highway Bonds. 20c.
220D. Road Models.
257D. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*314D. Methods for the Examination of Bituminous Road Materials. 10c.
*347D. Methods for the Determination of the Physical Properties of Road-Building Rock. 10c.
*370D. The Results of Physical Tests of Road-Building Rock. 15c.
386D. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387D. Public Road Mileage and Revenues in the Southern States, 1914.
388D. Public Road Mileage and Revenues in the New England States, 1914.
390D. Public Road Mileage and Revenues in the United States, 1914. A Summary.
407D. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
463D. Earth, Sand-clay, and Gravel Roads.
*532D. The Expansion and Contraction of Concrete and Concrete Roads. 10c.
*537D. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests. 5c.
*583D. Reports on Experimental Convict Road Camp, Fulton County, Ga. 25c.
*660D. Highway Cost Keeping. 10c.
*670D. The Results of Physical Tests of Road-Building Rock in 1916 and 1917. 5c.
*691D. Typical Specifications for Bituminous Road Materials. 10c.
*724D. Drainage Methods and Foundations for County Roads. 20c.
1216D. Tentative Standard Methods of Sampling and Testing Highway Materials, adopted by the American Association of State Highway Officials and approved by the Secretary of Agriculture for use in connection with Federal-aid road construction.
1259D. Standard Specifications for Steel Highway Bridges, adopted by the American Association of State Highway Officials and approved by the Secretary of Agriculture for use in connection with Federal-aid road work.

DEPARTMENT BULLETINS—Continued

No. 1279D. Rural Highway Mileage, Income, and Expenditures, 1921 and 1922.
1486D. Highway Bridge Location.

DEPARTMENT CIRCULARS

No. 94C. T. N. T. as a Blasting Explosive.
331C. Standard Specifications for Corrugated Metal Pipe Culverts.

TECHNICAL BULLETIN

No. 55. Highway Bridge Surveys.

MISCELLANEOUS CIRCULARS

No. 62M. Standards Governing Plans, Specifications, Contract Forms, and Estimates for Federal Aid Highway Projects.
93M. Direct Production Costs of Broken Stone.
*109M. Federal Legislation and Regulations Relating to the Improvement of Federal-aid Roads and National-Forest Roads and Trails. 10c.

FARMERS' BULLETIN

No. *338F. Macadam Roads. 5c.

SEPARATE REPRINTS FROM THE YEARBOOK

No. 914Y. Highways and Highway Transportation.
937Y. Miscellaneous Agricultural Statistics.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Connecticut.
Report of a Survey of Transportation on the State Highway System of Ohio.
Report of a Survey of Transportation on the State Highways of Vermont.
Report of a Survey of Transportation on the State Highways of New Hampshire.
Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio.
Report of a Survey of Transportation on the State Highways of Pennsylvania.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH

Vol. 5, No. 17, D- 2. Effect of Controllable Variables upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D- 3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 24, D- 6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D- 8. Tests of Three Large-Sized Reinforced-Concrete Slabs Under Concentrated Loading.
Vol. 11, No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

* Department supply exhausted

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

CURRENT STATUS OF FEDERAL AID ROAD CONSTRUCTION

AS OF

MARCH 31,1929

STATE	COMPLETED MILEAGE	UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FEDERAL-AID FUNDS AVAILABLE FOR NEW PROJECTS	STATE
		Estimated total cost	Federal aid allotted	MILEAGE			Estimated total cost	Federal aid allotted	MILEAGE				
				Initial	Stage[1]	Total			Initial	Stage[1]	Total		
Alabama	1,921.9	$ 3,756,211.95	$ 1,876,079.52	230.4	33.3	263.7	$ 162,471.28	$ 81,235.64	6.4		6.4	$ 2,558,238.91	Alabama
Arizona	884.2	1,444,239.33	1,182,402.79	49.5	24.1	73.6	372,580.68	280,515.94	17.0	9.9	26.9	3,395,947.69	Arizona
Arkansas	1,749.9	3,577,132.61	1,773,985.83	98.9	6.6	105.5	683,356.01	341,678.00	15.6		15.6	2,332,789.03	Arkansas
California	1,559.2	10,436,139.71	4,778,142.95	274.4	15.1	289.5	213,030.88	128,755.85	20.1		20.1	2,414,391 27	California
Colorado	1,072.9	3,577,382.55	1,871,790.74	144.6	32.5	177.1	367,235.60	203,580.12	17.9		17.9	2,855,461.80	Colorado
Connecticut	228.8	900,832.42	272,216.34	13.0		13.0	673,564.46	272,075.09	3.6		3.6	844,972.54	Connecticut
Delaware	213.0	295,099.10	147,549.55	8.0		8.0	668,398.50	233,909.50	13.7		13.7	226,981.22	Delaware
Florida	429.6	2,991,248.90	1,263,593.92	110.7	5.4	116.1						2,059,645.35	Florida
Georgia	2,521.0	4,272,526.21	1,925,612.67	195.3	36.9	232.2	159,857.81	79,557.19	13.4		13.4	2,026,964.34	Georgia
Idaho	1,126.8	1,152,767.94	686,951.47	86.8	3.0	89.8	91,186.67	54,816.95	5.7		5.7	979,459.67	Idaho
Illinois	1,815.6	20,015,962.78	8,930,212.36	603.9		603.9	1,051,302.52	523,777.59	39.3		39.3	2,948,997.89	Illinois
Indiana	1,256.1	5,814,901.11	2,781,515.66	173.8	3.5	177.3	2,938,334.04	1,422,000.75	100.1		100.1	854,192.31	Indiana
Iowa	2,967.6	3,541,656.92	1,419,866.58	49.2	107.8	157.0	4,145,323.14	1,842,667.47	58.4	102.4	160.8	43,642.49	Iowa
Kansas	2,386.2	5,582,677.60	2,212,582.61	364.6	2.2	366.8	171,232.65	64,960.36	9.4		9.4	2,208,731.99	Kansas
Kentucky	1,293.7	4,645,734.27	2,218,652.32	239.1		239.1	593,327.17	296,663.57	38.9		38.9	896,525.98	Kentucky
Louisiana	1,308.4	4,141,243.94	2,062,863.34	164.9		164.9	103,055.30	25,000.00	.1		.1	1,223,703.42	Louisiana
Maine	480.5	1,779,653.03	596,458.57	40.9		40.9	192,121.39	93,601.55	8.9		8.9	1,449,150.77	Maine
Maryland	621.4	459,798.80	194,190.00	13.7		13.7						665,255.03	Maryland
Massachusetts	568.3	3,403,182.61	1,082,522.70	64.3	.2	64.5	1,162,955.80	310,890.63	15.8		15.8	2,056,652.10	Massachusetts
Michigan	1,446.5	10,953,645.95	4,658,714.11	264.5		264.5	691,320.00	273,541.86	14.5	6.5	21.0	2,184,043.30	Michigan
Minnesota	4,089.8	1,249,220.75	350,618.27	96.1	11.2	107.3						2,147,297.96	Minnesota
Mississippi	1,640.1	4,860,241.98	2,213,071.52	220.0	6.4	226.4	273,196.97	136,598.90	22.0		22.0	1,430,410.79	Mississippi
Missouri	2,266.3	8,338,686.81	3,077,482.96	187.8	50.1	237.9	2,841,378.97	1,132,885.58	59.8	36.3	96.1	1,133,003.52	Missouri
Montana	1,540.0	4,144,946.44	2,627,233.60	266.6	7.6	274.2	708,024.23	371,948.65	79.6		79.6	4,765,642.43	Montana
Nebraska	3,523.5	2,916,140.08	1,451,767.49	281.1	103.7	384.8	598,646.02	299,322.97	26.0	57.7	83.7	3,284,939.12	Nebraska
Nevada	1,045.7	1,061,000.59	922,909.81	114.9	72.8	187.7	161,390.16	143,395.14	20.8	8.4	29.2	916,569.13	Nevada
New Hampshire	331.7	279,253.01	108,613.31	7.5		7.5						405,293.84	New Hampshire
New Jersey	451.7	4,892,260.81	839,820.00	56.0		56.0	113,525.78	28,425.00	1.9		1.9	864,555.08	New Jersey
New Mexico	1,801.1	2,847,372.51	1,799,109.84	199.3	5.1	204.4	370,507.18	236,198.30	13.0		13.0	1,075,247.20	New Mexico
New York	2,136.5	22,158,431.43	4,900,000.55	327.2		327.2	5,237,300.33	1,120,455.00	74.8		74.8	6,140,719.14	New York
North Carolina	1,679.7	1,810,380.07	905,190.00	73.1	11.2	84.3	278,423.66	139,211.82	17.3		17.3	1,978,588.21	North Carolina
North Dakota	3,658.6	2,870,044.89	1,243,329.91	432.1	92.2	524.3	1,037,941.77	346,516.39	190.0	119.0	309.0	1,306,607.01	North Dakota
Ohio	1,983.8	10,994,184.19	3,840,353.15	232.9	.1	233.0	3,288,623.39	786,150.19	46.0	9.8	55.8	3,720,609.23	Ohio
Oklahoma	1,732.1	3,133,422.29	1,414,637.35	103.7	37.7	141.4	882,136.94	413,038.12	37.4	7.1	44.5	1,266,390.74	Oklahoma
Oregon	1,147.8	463,683.00	272,996.77	37.2		37.2	61,358.00	38,183.08	6.0		6.0	2,222,515.58	Oregon
Pennsylvania	2,038.4	12,134,451.08	3,294,555.49	199.4		199.4	1,868,659.66	514,708.73	28.7	14.1	42.8	3,468,819.67	Pennsylvania
Rhode Island	165.2	396,745.71	89,340.00	6.0		6.0	274,697.74	108,825.00	7.2		7.2	776,149.23	Rhode Island
South Carolina	1,797.8	4,354,975.90	1,059,452.17	126.0	41.5	167.5						1,084,848.98	South Carolina
South Dakota	3,283.9	2,535,666.34	1,385,136.90	407.5	34.4	441.9	368,039.19	207,962.03	76.9		76.9	1,084,466.04	South Dakota
Tennessee	1,096.1	4,043,109.73	1,907,720.54	90.2	54.7	144.9	490,022.38	205,295.77	13.4		13.4	1,579,680.73	Tennessee
Texas	6,092.4	12,385,230.03	5,195,906.74	501.7	174.4	676.1	5,905,823.67	2,632,956.17	233.5	89.5	323.0	3,329,971.81	Texas
Utah	917.2	1,325,377.43	861,115.94	57.6		57.6	163,000.00	121,000.00	7.7		7.7	717,326.91	Utah
Vermont	229.0	965,465.68	288,777.15	20.5		20.5	376,582.99	123,030.00	8.2		8.2	292,715.06	Vermont
Virginia	1,327.7	2,303,173.74	997,146.17	56.4	15.2	71.6	597,576.07	272,424.50	15.9	3.7	19.6	1,131,187.37	Virginia
Washington	831.9	4,145,073.00	1,449,675.25	95.7	18.1	113.8						1,405,949.67	Washington
West Virginia	688.7	1,319,407.55	599,394.85	51.0	12.4	63.4						1,058,307.58	West Virginia
Wisconsin	2,106.3	4,185,638.92	1,809,323.96	124.4	4.9	129.3	352,692.78	176,335.00	16.3		16.3	3,056,665.63	Wisconsin
Wyoming	1,679.1	971,120.20	620,793.85	100.9		100.9						985,988.12	Wyoming
Hawaii	39.4	175,931.99	57,501.20	1.8		1.8	290,877.52	112,199.82	4.9		4.9	1,319,923.77	Hawaii
TOTALS	77,173.1	216,012,673.88	87,528,938.77	7,665.1	1,024.3	8,689.4	40,981,079.20	16,196,294.22	1,406.1	464.4	1,870.5	88,176,135.55	TOTALS

[1] The term stage construction refers to additional work done on projects previously improved with Federal aid. In general, such additional work consists of the construction of a surface of higher type than was provided in the initial improvement.