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LAYING COTTON FABRIC ON AN EXPERIMENTAL ROAD

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## *In This Issue*




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# COTTON FABRIC IN BITUMINOUS CONSTRUCTION

Reported by PAUL F. CRITZ, Senior Highway Engineer, Public Roads Administration

**In the search for new markets for surpluses of cotton that accumulated some years ago, considerable interest was evinced regarding the feasibility of using cotton fabric in low-cost bituminous road surfacing. Opinions were advanced that use of the fabric might permit more economical construction and could result in more durable roads.**

**Scattered early road-building experiments with cotton fabric were uncontrolled and therefore inconclusive. Laboratory tests indicated that the material might be of some benefit, but the extent was undetermined. Beginning in 1936, extensive field tests were undertaken in the use of cotton fabric in bituminous surfacing, and 400 miles of experimental roads were built in 24 States. Investigation of this work, which in many cases was carefully controlled, revealed that the use of cotton fabric materially increased the cost of construction but generally produced no important benefits.**

**This article is published to make available a record of the details of these experiments and of the conclusions drawn from them.**

THIS REPORT describes an investigation of the use of cotton fabric in bituminous highway construction and maintenance made cooperatively by a number of State highway departments and the Public Roads Administration. The investigation was prompted by the desire to improve the serviceability of low-cost bituminous surfaced roads by reducing costs, eliminating failures, and retarding deterioration. If the cotton fabric proved beneficial and economic in the reinforcement of bituminous surfaced roads, not only would improvement in service be obtained but an additional practical use would be found for a commodity of considerable importance to many States.

These objectives prompted early experimenting with cotton fabric in some of the Southern States. In 1926 an experiment was begun in South Carolina with fabric as a reinforcement for the bituminous surface treatments being constructed at that time and, by 1935, a number of experimental roads had been built which are described in some detail elsewhere.[1] Similar experimental roads were built in 1929 near Gonzales, Texas,[2] and in 1932 in Georgia [2] and Louisiana.[3]

The method of constructing these roads was similar in general to that used on many of the later experimental roads comprising the more extensive investigation described in this report. The road on which cotton fabric was to be used with a bituminous surface treatment was first cleaned of loose or foreign material and given a priming treatment of a bituminous material such as liquid asphalt, tar, or emulsion. Sometimes the cotton fabric was placed immediately after this application and sometimes it was placed after the priming material had penetrated into the nonbituminous base material and had dried.

The cotton fabric used was a fairly open, loosely woven cloth. Only a single thickness of cloth was used. In some cases a continuous strip of fabric was placed along each edge of the road and in others the full width of road being treated was covered with the fabric, using as many strips as necessary.

Following the placing of the fabric, alternate applications of bituminous materials and aggregate were spread and smoothed and the surface was then rolled. The types and quantities of materials used in these early experiments were those normally used by the particular State in the ordinary type of surface treatment. The use of the fabric had no appreciable effect upon the method of construction and none upon the appearance of the finished road surface. Only by markers placed for the purpose could the fabric sections be located after construction was completed.

These early experiments with cotton fabric in bituminous construction showed some promise but, because of the variable conditions under which the roads were built or resurfaced and the numerous types of fabric used, they did not offer a satisfactory basis for definite conclusions either as to the merits or limitations of cotton fabric or to the type of fabric best suited to the purpose. Data were not available to show whether the behavior of the experimental roads was due to the presence of the fabric or to other factors that have important effects on the behavior of bituminous-treated roads. Lack of information regarding the cost of construction and maintenance of these experimental roads made it impossible to determine whether apparent benefits were commensurate with the cost.

### LABORATORY TESTS SHOWED FABRIC OF LITTLE VALUE

To provide desirable information on the merits and limitations of cotton fabric as a reinforcement for thin bituminous surfaces the Public Roads Administration conducted a laboratory investigation at the Arlington Experiment Farm in 1935.

This investigation included physical tests of bituminous mixtures with and without fabric and a service test of fabric in a normal bituminous surface treatment of the type for which the fabric was believed to be most practical. The physical tests of bituminous mixtures reinforced with and without fabric showed that the fabric neither added tensile strength to the mixtures nor reduced the tendency of the mixtures to crack under load. The behavior of the mixtures under test was practically the same whether or not fabric was used.

The service test was designed to simulate actual service conditions and was conducted on the indoor circular track which has been described in detail in PUBLIC ROADS.[4] The track was a circular trough 12 feet in diameter, 12½ inches deep, and 18 inches wide. A narrow inner trough served as a reservoir through which water could be introduced into the base and held at any desired level.

[1] Cotton-Fabric-Reinforced Roads by W. K. Beckham and W. H. Mills. Engineering News-Record, October 3, 1935, page 453.
[2] Cotton Fabric for Reinforcing Bituminous Surfaces on Highways, Highway Research Abstracts, No. 32, July 1936, p. 4.
[3] Cotton Cloth Used to Waterproof Road Surface by Arnold Davis. Engineering News-Record, August 18, 1932, page 194.
[4] Circular Track Tests on Low-Cost Bituminous Mixtures, by C. A. Carpenter and J. F. Goode, PUBLIC ROADS, vol. 17, no. 4, June 1936.

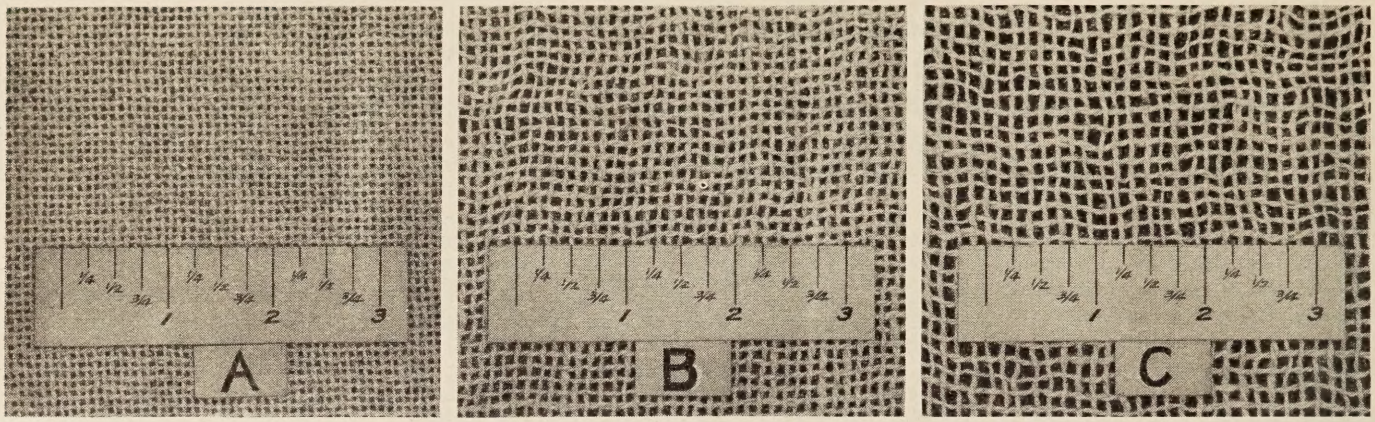


FIGURE 1.—THE TYPES OF COTTON FABRIC A, B, AND C USED IN BITUMINOUS CONSTRUCTION HAD 12, 9, AND 7 THREADS PER INCH AND WEIGHED 5.30, 4.25, AND 3.20 OUNCES PER SQUARE YARD, RESPECTIVELY. THE COST WAS 7.6, 6.1, AND 4.6 CENTS PER SQUARE YARD OF ROAD SURFACE F. O. B. DESTINATION.

Two automobile wheels, equipped with 6.00 by 20 low pressure tires inflated to 35 pounds pressure and mounted on the ends of a centrally pivoted steel beam, were used for compacting the base and surface courses and for testing the wearing surface. The entire weight of the wheel and beam assembly, which was carried by the test surface, was 1,600 pounds or 800 pounds per wheel. This test load was later increased to 1,000 pounds per wheel.

A bituminous surface treatment with a supporting base of sand-clay-gravel was selected for the test. Two classes of base were used: One was composed of materials that met the requirements for satisfactory base-course materials; the other was composed of materials definitely inferior in quality. On each of these bases, two sections of bituminous surface treatment were constructed which were identical except that one section contained cotton fabric and the other did not.

The sand-clay-gravel bases were thoroughly compacted and then primed with one-fourth gallon of tar per square yard. The fabric used in the two reinforced sections was placed in the tar prime while it was still wet. Twenty-four hours later 0.2 gallon of hot tar per square yard was spread on the surface, covered with 35 pounds per square yard of crushed limestone and then lightly rolled. Following this operation 0.3 gallon of hot tar per square yard was spread and covered with 10½ pounds of ⅜-inch crushed limestone and 4½ pounds of coarse sand. Thorough rolling completed the surface treatment.

The test consisted of subjecting the surface to traffic simulated by the automobile wheels. No apparent change occurred in the surface until water was admitted to the base course, after which failures began to develop. Testing continued until practical destruction of the surfaces had occurred. The results of this test may be summarized briefly as follows:

1. On the satisfactory base there was no significant difference between the section that contained fabric and the one that did not.

2. On the base of inferior quality the section containing fabric remained in a satisfactory condition under traffic for a period approximately 25 percent longer than the section without fabric.

3. The test indicated that the fabric might be of some value under certain conditions but the extent of benefit could not be determined from this test.

At the conclusion of the test run, mat samples were removed from the sections laid on both types of bases and the fabric contained in them was recovered. In both instances the fabric had been nearly destroyed.

#### SEARCH FOR NEW USES OF COTTON AN INCENTIVE TO FURTHER EXPERIMENT

Because of the great surplus of cotton that had accumulated, Congress in 1936 authorized the Department of Agriculture to purchase large quantities of cotton for the purpose of promoting and encouraging its use in new fields. Considerable interest developed regarding the feasibility of using cotton fabric in low-cost types of bituminous construction. Opinions were advanced that fabric would act as a reinforcement for holding intact the edges which are the weakest points in thin bituminous surfaces; that the fabric, when impregnated with tar or asphalt, would serve as a membrane which would waterproof the road base and thereby lessen or eliminate the destructive effects of moisture; that less expensive base construction would be required; and that a practical use could be made of certain grades of cotton staple for which the demand was not great.

It was believed that by using some of this cotton in highway construction under a variety of known conditions, sufficient data might be accumulated to provide definite information as to its value and limitations. Accordingly, the Department of Agriculture, after preliminary laboratory study and experimenting, prepared specifications for three types of fabric believed suitable for an experimental program. These specifications are given in the appendix (*page 274*). The fabrics produced under them are shown in figure 1.

The fabric was furnished without charge by the Department to the State highway departments on the condition that it be used in highways constructed in an approved manner and that reasonable care be taken in obtaining data on the service behavior and cost of maintaining the roads in which it was used so that evaluation might be made of the benefits derived.

#### EXTENSIVE FIELD TESTS WERE UNDERTAKEN

Twenty-four States requested approximately 6,000,000 square yards of fabric; enough to surface more than 500 miles of 20-foot roadway. Although the original specifications provided for three widths of

Table 1.—*Extent of experimental use of cotton fabric*

| State | Fabric supplied | Sections reported | Fabric reported used [1] | | | | Lengths of road in which fabric reinforcement was used | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Type A | Type B | Type C | Total | Type A | Type B | Type C | Total |
| | *Square yard* | *Number* | *Square yard* | *Square yard* | *Square yard* | *Square yard* | *Miles* | *Miles* | *Miles* | *Miles* |
| Alabama | 1, 250, 650 | 18 | 361, 013 | 367, 318 | 327, 968 | 1, 056, 299 | 30. 02 | 30. 54 | 27. 27 | 87. 83 |
| Arizona | 115, 473 | [2] 3 | 1, 993 | ---------- | 1, 806 | 3, 799 | . 12 | ---------- | . 15 | . 27 |
| Arkansas | 122, 996 | 2 | 30, 189 | 31, 958 | 30. 191 | 92, 338 | 2. 51 | 2. 66 | 2. 51 | 7. 68 |
| California | 66, 000 | 6 | 5, 312 | 13, 593 | 12, 885 | 31, 790 | . 40 | 1. 30 | . 98 | 2. 41 |
| Florida | 54, 118 | 1 | 17, 402 | 17, 720 | 17, 752 | 52, 874 | 1. 45 | 1. 47 | 1. 47 | 4. 39 |
| Georgia | 144, 321 | 3 | 36, 079 | 36, 732 | 36, 079 | 108, 890 | 3. 00 | 3. 05 | 3. 00 | 9. 05 |
| Indiana | 113, 957 | 2 | 37, 986 | 37, 986 | 37, 986 | 113, 958 | 3. 50 | 3. 50 | 3. 50 | 10. 50 |
| Maine | 18, 186 | 1 | 6, 050 | 5, 626 | 5, 809 | 17, 485 | . 50 | . 46 | . 48 | 1. 44 |
| Massachusetts | 43, 412 | 3 | 15, 990 | 15, 340 | 10, 559 | 41, 889 | 1. 47 | 1. 41 | . 97 | 3. 85 |
| Michigan | 447, 975 | 9 | 117, 413 | 120, 275 | 113, 715 | 351, 403 | 8. 90 | 9. 11 | 8. 62 | 26. 63 |
| Mississippi | 109, 330 | 3 | 11, 042 | 23, 889 | ---------- | 34, 931 | . 92 | 1. 98 | ---------- | 2. 90 |
| Missouri | 257, 400 | 6 | 87, 033 | 76, 970 | 79, 672 | 243, 675 | 6. 60 | 5. 83 | 6. 03 | 18. 46 |
| Montana | 39, 600 | 1 | 13, 200 | 13, 200 | 13, 200 | 39, 600 | 1. 00 | 1. 00 | 1. 00 | 3. 00 |
| Nevada | 66, 116 | 1 | 13, 200 | 13, 200 | 13, 200 | 39, 600 | 1. 00 | 1. 00 | 1. 02 | 3. 02 |
| New Hampshire | 21, 706 | 1 | 7, 017 | 7, 297 | 6, 886 | 21, 200 | . 64 | . 67 | . 63 | 1. 94 |
| New Jersey | 102, 497 | 5 | 31, 949 | 36, 969 | 29, 874 | 98, 792 | 2. 62 | 3. 14 | 2. 49 | 8. 25 |
| New York | 842, 097 | 21 | 217, 405 | 230, 801 | 238, 040 | 686, 246 | 18. 53 | 20. 03 | 20. 70 | 59. 26 |
| North Carolina | 1, 115, 178 | 17 | 314, 563 | 314, 765 | 313, 784 | 943, 112 | 27. 44 | 27. 48 | 27. 38 | 82. 30 |
| Oregon | 36, 166 | 1 | 11, 518 | 11, 396 | 11, 518 | 34, 432 | . 95 | . 94 | . 95 | 2. 84 |
| Rhode Island | 125, 096 | [3] 2 | 2, 676 | 2, 676 | 4, 334 | 9, 686 | . 05 | . 05 | . 05 | . 15 |
| South Carolina | 669, 951 | 18 | 210, 611 | 206, 302 | 208, 691 | 625, 604 | 16. 57 | 16. 24 | 16. 34 | 49. 15 |
| Tennessee | 72, 089 | 1 | 13, 844 | 23, 836 | 14, 534 | 52, 214 | 1. 15 | 1. 98 | 1. 21 | 4. 34 |
| Virginia | 89, 482 | 7 | 24, 038 | 34, 455 | 22, 942 | 81, 435 | 1. 79 | 2. 68 | 1. 72 | 6. 19 |
| Washington | 117, 006 | 7 | 30, 078 | 25, 161 | 25, 528 | 80, 767 | 2. 48 | 2. 07 | 2. 11 | 6. 66 |
| Total | 6, 040, 802 | [4] 139 | 1, 617, 601 | 1, 667, 465 | 1, 576, 953 | 4, 862, 019 | 133. 56 | 138. 27 | 130. 68 | 402. 51 |

[1] When amounts of each type used were not specifically stated, it was assumed that equal amounts of each type were used.
[2] Types and amounts not given for two sections. [3] Includes one road section only. No other information reported.
[4] Two types of construction were employed on each of two sections.

material, the fabric was actually furnished in widths ranging from 56 to 90 inches, depending upon the width of the road to be surfaced. In order to provide information on the type of fabric best suited for the purpose, each width was furnished in approximately equal quantities of the three weights and weaves. Type A weighed 5.30 ounces per square yard and had a thread count of 12 per inch in each direction. Type B weighed 4.25 ounces per square yard and had a thread count of 9 per inch. Type C weighed 3.20 ounces and had a thread count of 7 per inch.

Taking into account the overlapping of adjacent strips of fabric, the average cost per square yard of road surface of the three types of fabric at the points of delivery was: Type A, 7.6 cents; type B, 6.1 cents; and type C, 4.6 cents. The average of the reported costs of handling on the job was 1.25 cents per square yard.

Experimental sections were constructed in each of the 24 States that requested fabric and approximately 80 percent of the fabric furnished was reported as having been placed in service. The amount of fabric furnished, the number of sections constructed, and the amount of fabric used therein are shown for each State in table 1. The types of construction used were as follows:

| *Type of construction* | *Number of sections reported* |
|---|---|
| Surface treatment | 99 |
| Plant mix | 15 |
| Road mix | 12 |
| Seal treatment on road mix | 2 |
| Surfacing wooden bridge floors | 10 |
| Bituminous shoulder treatment | 2 |
| Base reinforcement | 1 |
| Total | 141 |

### USE OF FABRIC DID NOT COMPLICATE CONSTRUCTION

Practically all types of low-cost bituminous construction and re-treatments are represented by these experimental sections, which were built in all parts of the country. Variations in temperature and moisture conditions likely to be found in any State are believed to be represented. The types of soil and character of bases upon which the experimental surfaces were built, as well as the types of bituminous materials and aggregates used, also include many kinds, so that in general any set of conditions normally encountered in this country was represented in the experiments.

The use of fabric did not involve any serious construction difficulties despite the fact that in practically all instances contractors, maintenance crews, and engineers alike were without experience in its use in bituminous construction and there was little information available to guide them. Many questions were raised relative to the procedure best suited to insure success of the experiments. Chief among these were: The allowance to be made for absorption of bitumen by the fabric; the relative merits of asphalt and tar for impregnating the fabric; the time of placing the fabric, that is, in the fresh prime or after the priming application had dried; satisfactory methods of holding the fabric in place; and protection of the fabric in place during subsequent construction operations. Since specific information on these matters was not available, the rules of common sense based upon general construction experience were followed.

Allowance for absorption varied from practically none to 0.05 gallon of material per square yard, depending upon the weight of the fabric. Both tar and asphalt were used as priming materials. Fabric was placed in the fresh prime on many experimental sections and on the dried primed base on many others. Various methods of holding the fabric in place were reported to have been used. When the fabric was placed in the wet prime it was sometimes fastened and sometimes it was not. Fastening devices included roofing nails and common fence staples, and were spaced at intervals ranging from 3 feet to 50 feet. They were placed only on the outside edges of the outer strips in some instances and in other instances both edges of all strips were fastened. When laid on the dried primed base, some type of fastener had to be

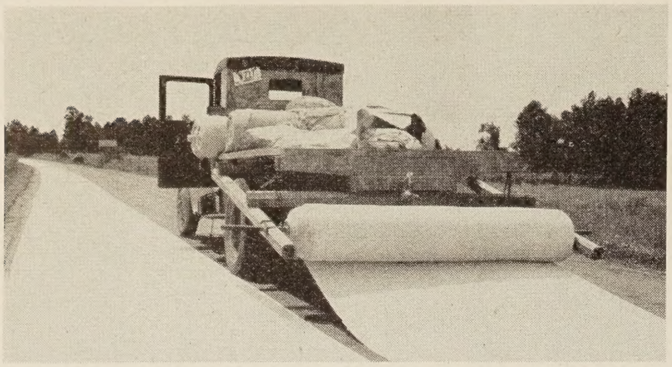

FIGURE 2.—LAYING COTTON FABRIC WITH A TRUCK-MOUNTED REEL.

used to prevent displacement of the fabric by the wind. Methods reported included use of roofing nails, staples, and small amounts of bituminous material spotted at intervals along the edges. In some instances small amounts of sand or fine stone or of bituminous mixture were spread on the fabric prior to surfacing operations but in most instances the fabric was not covered except by the normal operation that followed.

The wide range in reported costs of handling and placing the fabric includes actual costs accurately kept in some instances as well as contractors' bid prices. Having no experience as a guide to bidding on such items the contractors naturally set prices that could be expected to insure no loss on that item. However, on one of four special cooperative experimental sections where the work was done by State forces all items chargeable to actual handling and laying of the fabric totaled 0.16 cents per square yard. This particular road was built in a State where considerable early experimenting had been done and where some general information was available.

#### FABRIC USED IN NEW CONSTRUCTION AND IN RESURFACING

Fabric was used both in new construction and in the re-treatment, or resurfacing, of old bituminous surfaces. In new construction, where a wearing surface was laid on a nonbituminous base composed of such materials as topsoil, sand-clay, clay-gravel, stone, or chert, the base was first primed with a liquid bituminous material such as tar or asphalt. The fabric was then placed on the primed base and the bituminous surface constructed in the usual manner.

Where the bituminous surface mat was to be constructed of plant-mixed material, the fabric was generally given a tack coat of liquid bituminous material prior to placing the surface mixture. Where the surface mat was to be constructed by making alternate applications of bituminous material and aggregates, the fabric was impregnated by the first application of bitumen.

In re-treatment work where a new surface was being built on an old bituminous surface, the fabric was laid directly on the old surface and then given a tack coat of bituminous material, after which the new surface was constructed in the usual manner.

The fabric, which came in rolls, was rolled out over the surface in a longitudinal direction with adjoining strips overlapping 2 or 3 inches. Three or more strips were ordinarily used, the number depending upon the width of the surface, the width of the fabric used, and whether full width or half width construction was employed. After placing, the fabric was smoothed to remove wrinkles.

Placing of the fabric was done in various ways. Sometimes the rolls were laid on the base and rolled forward by hand. Sometimes they were suspended from the rear end of a truck and the fabric unrolled as the truck moved forward. In another method the roll was suspended on a pipe carried by two men or supported by a pair of wheels. The method used on a particular job depended upon the men and equipment available and upon the preference of the engineer in charge. Two of the methods used are shown in the cover illustration and figure 2.

On new construction, the fabric was sometimes laid immediately after the prime application so that it would be impregnated with the priming material and would be held firmly in place as the latter dried and hardened. Sometimes it was laid after the priming material had penetrated and dried thoroughly and was then impregnated with the subsequent applications of bituminous material. Figure 3, A shows the fabric laid in the wet prime and figure 3, B shows the fabric laid on the dried primed base. In both instances the fabric was ready for the subsequent applications of bitumen and aggregate or plant-mixed material.

Various methods were used to prevent displacement of fabric by the wheels of the distributors while spreading bituminous material. Sometimes a small amount of aggregate was spread first and sometimes the distributor wheels were wiped with a mixture of kerosene and light lubricating oil. In many instances, however, satisfactory results were obtained simply by keeping the distributor wheels clean and dry. As long as the wheels did not come in contact with the bituminous materials being applied, no difficulty was encountered because of fabric being displaced. Figure 4, A shows the distributor wheels being oiled just prior to applying hot asphalt on the impregnated fabric. Figure 4, B

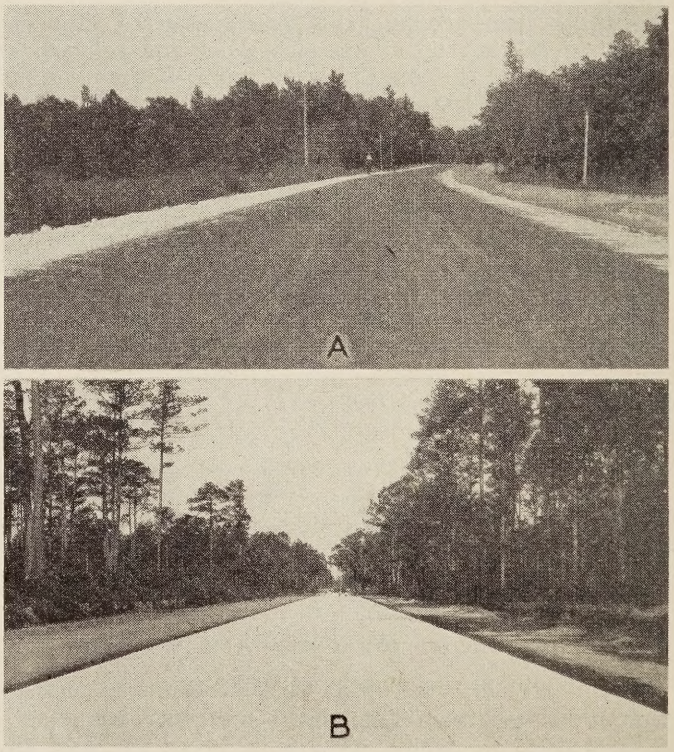



FIGURE 3.—FABRIC WAS IMPREGNATED BY LAYING IT IN WET PRIME (A) OR WAS PLACED ON A DRIED PRIMED BASE (B) BEFORE APPLYING HOT BITUMINOUS MATERIAL.

shows the distributor applying the hot asphalt. On this section no special precautions were taken, except to keep the wheels clean, and no trouble was met.

#### FOUR SPECIAL SECTIONS INCLUDED IN THE EXPERIMENT

Among the many sections constructed with cotton fabric were four special experimental roads in which the Public Roads Administration actively cooperated with the State highway departments of Alabama, North Carolina, South Carolina, and Tennessee. In these special experiments the roads were constructed in accordance with the standard practice of the State in which built, but more information regarding them was obtained than is ordinarily deemed necessary in routine construction. An examination of the base and subgrade materials was made prior to construction so that sections containing the different weights of fabric and one section without fabric could be constructed on bases having the same characteristics in order that a proper evaluation of future service behavior could be made. On each experimental road the bituminous construction was the same for all sections except that a slightly greater amount of bituminous material was used on the fabric sections to compensate for the absorption of the bitumen by the fabric.

Construction of the Alabama cooperative experimental road was completed in November 1936. About 6 miles of road were reinforced with fabric. The bituminous mat was constructed by the double surface treatment method. The soil base was chert. On this road each of the three types of fabric was laid in two ways: (*a*) Immediately after the tar prime had been applied and (*b*) after the prime had dried and hardened. The bituminous binder was hot asphalt for the first application and rapid-curing cut-back asphalt for the seal coat applications. The cover was crushed slag.

The North Carolina cooperative experimental road was completed in June 1937. It was 14½ miles long and contained approximately 8 miles of road reinforced with fabric. The base was composed of sand-clay mixtures that varied in plasticity. Construction was controlled to provide four groups of sections whose plasticity indexes were nonplastic to 4, 4 to 8, 6 to 10, and 12 to 16, respectively. In each group, sections were constructed with and without fabric. The bituminous construction was very similar to that employed on the Alabama experimental road except that the fabric was laid only after the primed base was dry. The cover aggregate was crushed stone.

The South Carolina cooperative experimental road was completed in September 1937. It was 6.7 miles in length and contained approximately 3 miles of road reinforced with fabric. The base was topsoil and was very uniform in its soil characteristics except as to the grading of the topsoil particles. On this road, eight sections were constructed, four containing fabric and four without fabric. Bituminous construction was approximately the same as that used on the North Carolina experimental road except that the liquid bituminous materials used in the seal treatment were a rapid-curing cut-back asphalt on some sections and a quick-breaking asphaltic emulsion on others.

The Tennessee experimental road was completed in August 1937. It was about 8 miles in length and contained approximately 3 miles of road reinforced with fabric. The base on most of the road was cherty clay, stabilized under traffic with crushed stone. On one short portion a waterbound macadam base was built.


Figure 4.—(A) Oiling the Distributor Wheels Prevented Disturbing Impregnated Fabric. Paper Strips Under the Wheels Kept Oil From Dripping. (B) Applying Hot Asphalt Binder on Fabric Laid on Dried Primed Base. (C) Trucks Immediately Following the Distributor Backed up and Spread the Cover Stone Uniformly.

Two types of bituminous contruction were employed. One was the surface-treatment type similar to that used in the other three States, where the fabric was laid on the primed soil base. The other was the road-mix type in which the bitumen and aggregate were mixed on the road, leveled, and compacted by rolling. After a short period of time under traffic, a seal treatment was applied and on this part of the experimental road the fabric was laid on top of the road-mixed mat immediately before applying the seal treatment.

Three of these experimental roads were built by contract and one by State forces. The methods used in each were those required by the State standard specifications and were essentially the same as those used throughout the country for similar types of contruction.

#### METHOD OF PLACING SURFACE TREATMENT DESCRIBED

The method of placing the surface treatment was very similar on all four experimental roads and was done

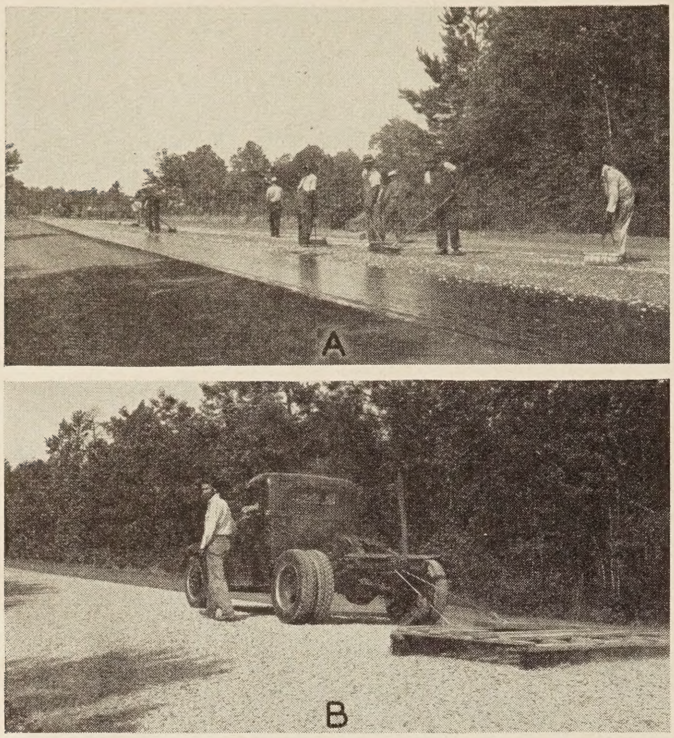


FIGURE 5.—(A) INITIAL HAND-BROOMING INSURED UNIFORM AGGREGATE COVERAGE. (B) A FIBER BROOM DRAG COMPLETED THE SPREADING WHICH WAS FOLLOWED BY MODERATE ROLLING.

essentially as follows: After the fabric had been placed as previously described, hot bituminous material was applied directly on the fabric. Immediately following this application, crushed stone or slag was spread from trucks provided with tail-gate spreaders, care being taken to keep the truck wheels always on the cover material. This operation is illustrated in figure 4, C. To insure uniform coverage, the trucks were all loaded uniformly either by using a strike-off board or by weighing each load, and each load was spread over a measured distance. When the cover material had been spread from the trucks it was lightly broomed by hand and with a fiber broom drag as shown in figure 5, A and B. When the cover had been spread uniformly so that no uncovered area or areas containing an excess of material remained, the surface was rolled and immediately opened to traffic for a short period during which time hand-spotting, brooming, and rolling were continued intermittently to insure seating all the cover.

A seal coat was applied either immediately or after the treatment had been subjected to traffic for periods not exceeding 3 weeks. The seal coat consisted of two applications of a liquid bituminous material and one spread of ⅜-inch maximum size aggregate. The total amount of liquid bituminous material used was approximately the same as that of the hot-application material but the fine aggregate used was about half the amount of the coarser aggregate used with the hot-application material. The fine aggregate was spread after the first application of liquid bitumen and with the same uniformity and care used with the coarser aggregate. It was either broomed or broomed and rolled before the second application of liquid bitumen was made, depending upon whether the seal stone was to be penetrated by the application or mixed with it. Sealing in this manner adds practically no thickness

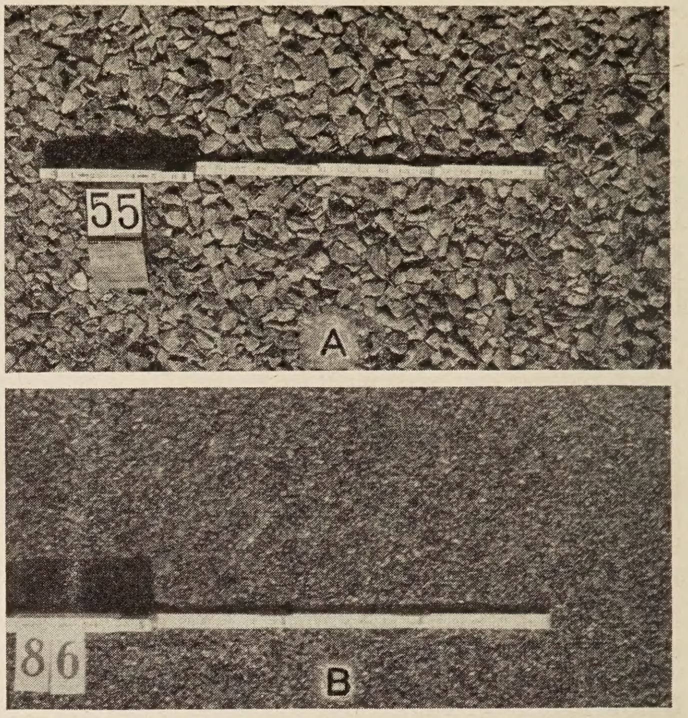


FIGURE 6.—(A) A TYPICAL SURFACE AFTER 20 DAYS OF TRAFFIC PRIOR TO SEAL COAT APPLICATION. (B) A WELL-SEALED SURFACE TREATMENT. USE OF FABRIC IN THESE SURFACES HAD NO EFFECT ON THEIR APPEARANCE.

to the mat, as the small particles fill the interstices in the coarser stone. The small stones also reduce the rough texture of the surface and give it a pleasing appearance. Because of the relative richness of the bituminous material, the seal coat provides a waterproof surface. The presence of fabric in this type of construction influences neither the type of seal coat used nor the methods of constructing it. Figure 6, A is a typical view of a completed surface before the seal treatment was applied and figure 6, B is a typical view of a well-sealed surface.

### SPECIAL EXPERIMENTAL ROADS WERE INSPECTED IN DETAIL

A detailed inspection of these four special experimental roads was made in October 1938 by the author. On three of them, samples of the bituminous mats were taken and the fabric was recovered for examination. In all, 14 samples were taken, 2 of which were cut from areas where softening of the soil base had caused the bituminous mat to settle and crack. The remaining 12 samples were taken from areas that were in excellent condition and that had neither required nor received any maintenance since construction. No evidence of movement of the base or of the surface was apparent in the good areas.

Without exception the fabric in the samples taken was in an unsatisfactory condition and in many instances it was practically destroyed. On these sections it not only had not prevented failures caused by inferior base material but it did not remain in good condition even where base and surface failures had not occurred. Figure 7, A shows the only unsatisfactory area on one of the cooperative experimental roads some 18 months after construction. The type A fabric removed from this area is shown in figure 7, B and as might be expected its condition was very poor. Figure 7, C is a general view of a section of another co-

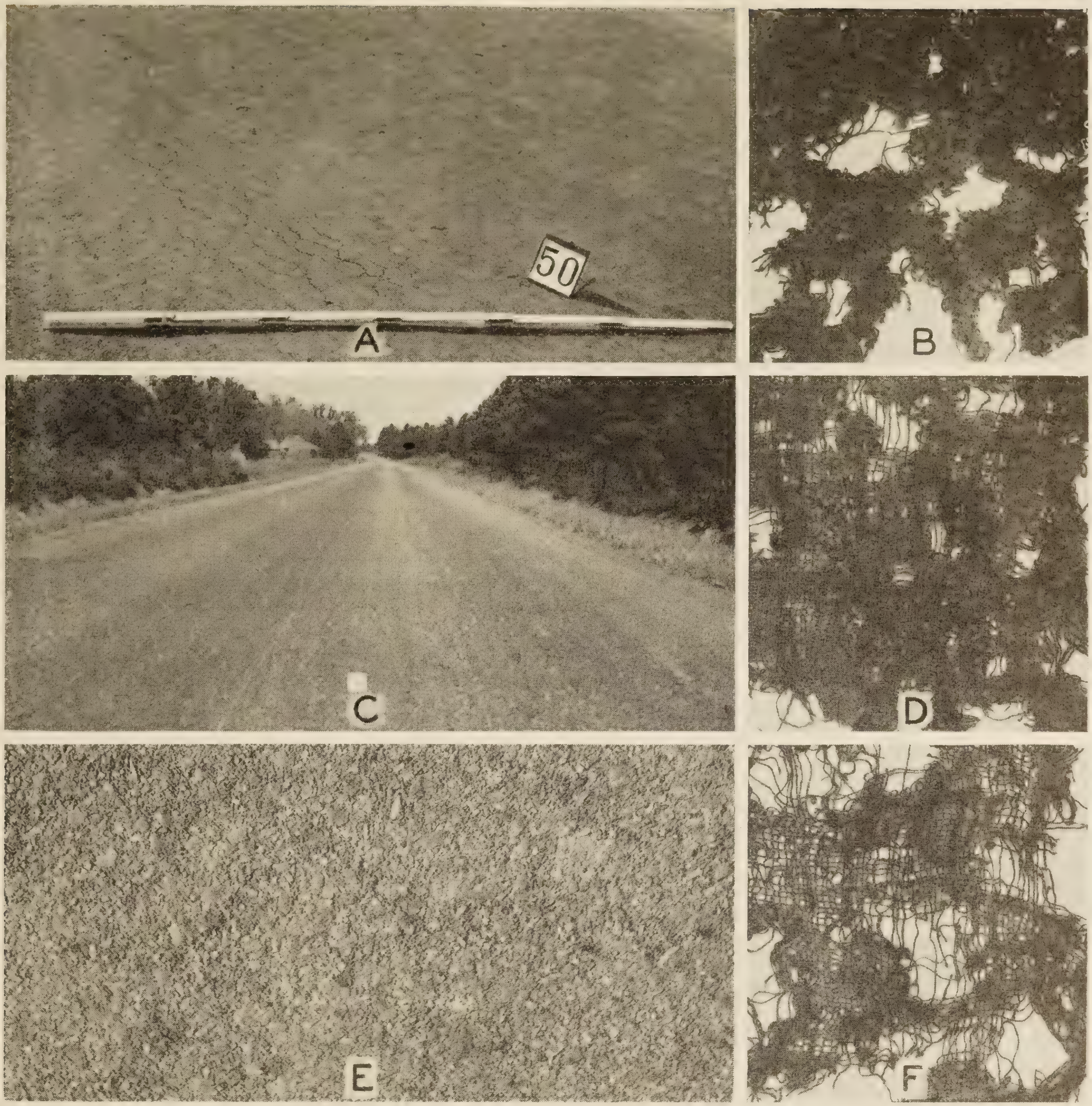


FIGURE 7.—RECOVERED FABRIC WAS FOUND BADLY DETERIORATED AND INCAPABLE OF AFFECTING FUTURE BEHAVIOR OF THE ROAD. (A) FAILURE OF THIS ROAD DUE TO A POOR BASE WAS NOT PREVENTED BY THE USE OF TYPE A FABRIC. (B) THE MATERIAL RECOVERED WAS IN POOR CONDITION. (C) THIS ROAD WAS IN EXCELLENT CONDITION AFTER A YEAR OF SERVICE EVEN THOUGH THE TYPE B FABRIC USED IN IT HAD PARTIALLY DISINTEGRATED (D). THE FINE APPEARING SURFACE (E) ADJOINED THAT SHOWN IN (C). THE TYPE C FABRIC RECOVERED FROM IT WAS NEARLY DESTROYED (F).

operative experimental road which was in excellent condition throughout its length 1 year after construction. The type B fabric removed from the area shown was not in good condition as is shown by figure 7, D. Similarly, figure 7, E shows a nearby area in excellent condition but the type C fabric removed from it was practically destroyed as shown by figure 7, F.

#### MANY OTHER FABRIC-REINFORCED ROADS WERE EXAMINED

In addition to these four cooperative experimental roads 80 other sections containing cotton fabric were inspected by the author in the fall of 1938 and the spring and summer of 1939. These sections were located in 16 States and contained more than 225 miles of road reinforced with fabric. The fabric was used in new construction and in the re-treatment of old bituminous surfaces. In both cases the new mat was constructed either by the surface-treatment method, the road-mix method, or by using plant-mixed material.

The use of the surface-treatment method, since it involved no manipulation other than light brooming and rolling, presented no special difficulty or change in

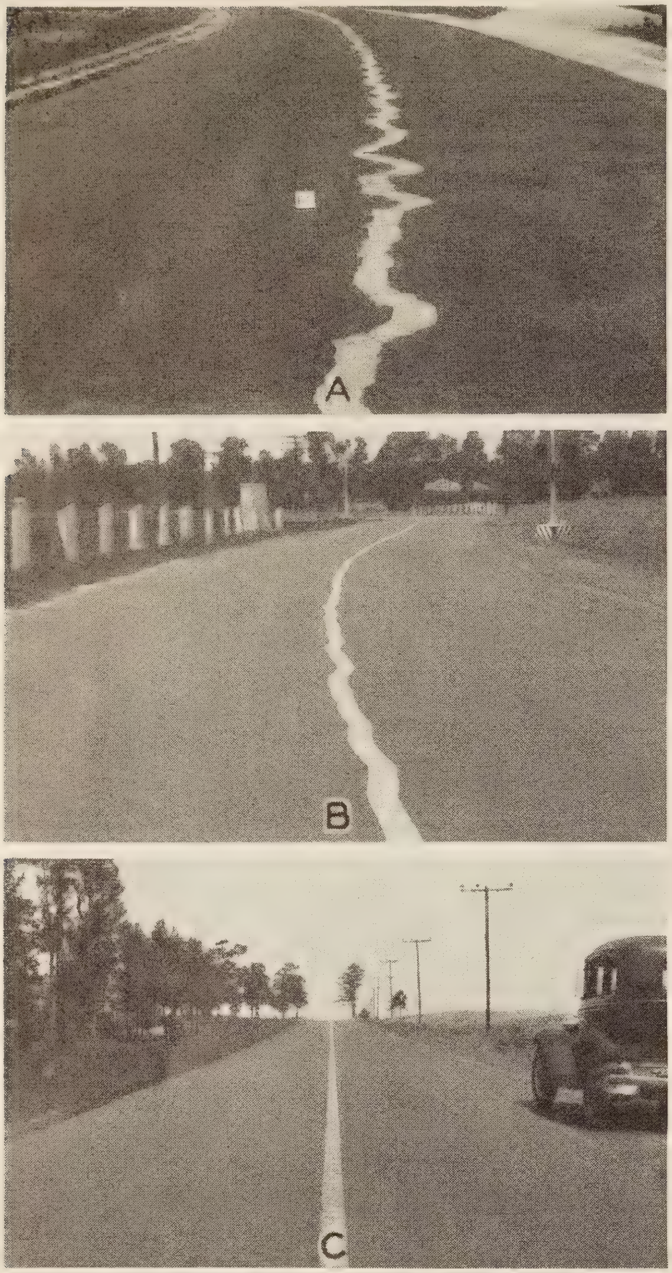


Figure 8.—Where Fabric Was Used in the Re-treatment of an Old Surface, the New Mat Sometimes Slipped Laterally. Movement, as Shown by the Center Stripe, Was Greater in the Surface Containing Type A Fabric (A) and Was Less in the Surface Containing Type C Fabric (B). No Slippage Occurred Where Fabric Was Not Used (C).

method of operation on sections that contained fabric.

Road mixing might not appear practicable where fabric was being used but one State found this method to be very satisfactory in re-treatment work provided sand was spread on the fabric immediately after it had received an application of bitumen. Additional aggregate and bitumen were then spread and road mixed. The thin blanket of impregnated sand provided a protective cover for the fabric during the mixing operation which, however, had to be carried on rather carefully. It was anticipated that any sand not held by the initial application of bitumen either would be incorporated in the mix or would be impregnated by the liquid bitumen used in the mix, so that no uncoated sand would be left between the fabric and the mixed material.

A number of the sections inspected were constructed in this manner and, in general, they were in excellent condition. No difference between the sections with and without fabric could be seen. On only one project were failures observed that apparently were not attributable to inadequate base support. In this instance pot holing had occurred on the sections where fabric was used and had extended through the mix proper, exposing a thin layer of bitumen-coated sand above the fabric. Here, apparently, a layer of uncoated sand had prevented the road mix from bonding to the old surface and to the fabric.

When plant-mixed material was used in constructing a new surface or re-treating an old one, some difficulty was reported in the construction operation where spreader boxes were pulled on skids or where mechanical finishers were used, unless the fabric was protected by first spreading a small amount of the prepared mixture on it. On the sections that did not contain fabric such precautions were unnecessary, of course.

Regardless of the type of construction, the failures that occurred were as prevalent on the fabric sections as on those without it. In addition, one type of failure seen only on sections where a surface treatment mat had been laid on an old bituminous surface was the tendency displayed by the mat containing fabric to slip. On one road the slippage was greatest on the type A fabric sections, less pronounced on the type B fabric sections, and least noticeable on the type C fabric sections. No slipping had occurred on the sections that did not contain fabric. Figure 8, A, B, and C illustrates this rather unexpected behavior.

#### FABRIC USED ON WOODEN BRIDGE FLOORS

In a number of States fabric was used in the bituminous surfacing of wooden bridge floors. Reports indicate that satisfactory results were obtained where the bridge deck was rigid. Ordinarily, when used on wooden floors the fabric was tacked to the deck and the bituminous mat was then constructed in the usual way.

It was reported that the fabric did not necessarily prevent fine hair cracks from forming over the spaces between the planks but that it did prevent raveling of the mat at the edges of such cracks and assisted in holding the mat together, thereby making a waterproof covering for the wooden floor and reducing its tendency to decay. On two adjoining wooden bridges in South Carolina that carry the same traffic and are identical in construction, fabric was laid on the floor of one bridge and not on the other immediately prior to constructing a bituminous surface mat. The mat containing the fabric had remained in excellent condition up to the time of the inspection. It furnished a waterproof covering for the untreated timber floor and stringers which likewise remained in good condition. Although the green planks with which the floor was laid had shrunk on drying and gaps up to one-half inch in width developed between them, only a thin hair crack developed in the bituminous mat. So waterproof was this covering that it became necessary to bore holes through it and the bridge floor in order to drain surface water from low areas. Its condition when inspected in 1938 is shown by figure 9, A.

In contrast to this excellent behavior is that of the adjoining bridge where fabric was not used. As shown in figure 9, B, the surface cracks are much wider.

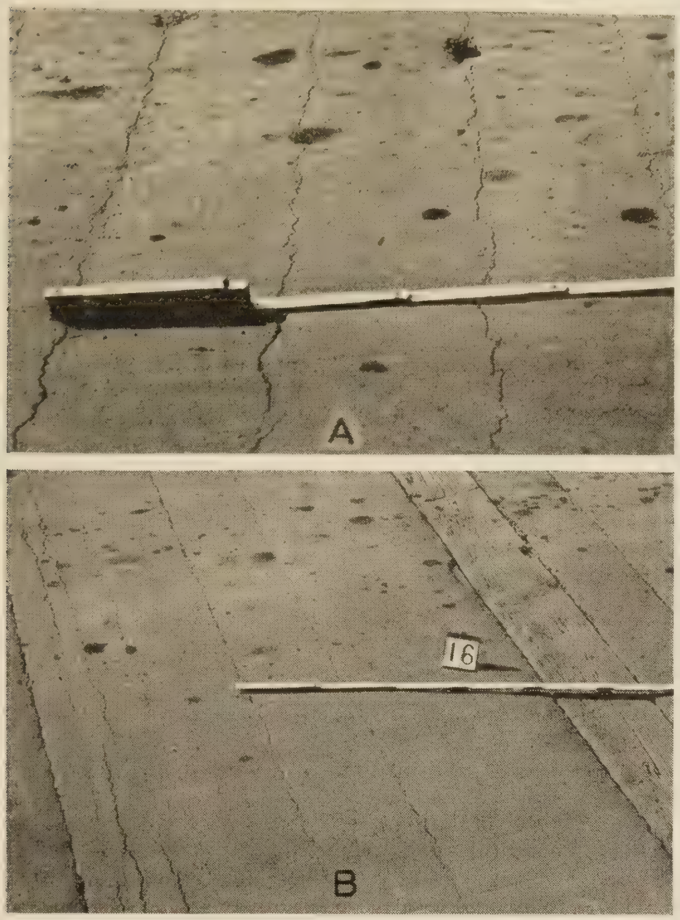


Figure 9.—(A) On a Rigid Wooden Bridge Floor, Fabric Did Not Prevent Narrow Joint Cracks But Did Stop Raveling of the Surface. (B) On a Similar Bridge Where Fabric Was Not Used the Surface Cracked and Raveled Extensively, Exposing the Floor Planks and Allowing Them To Rot.

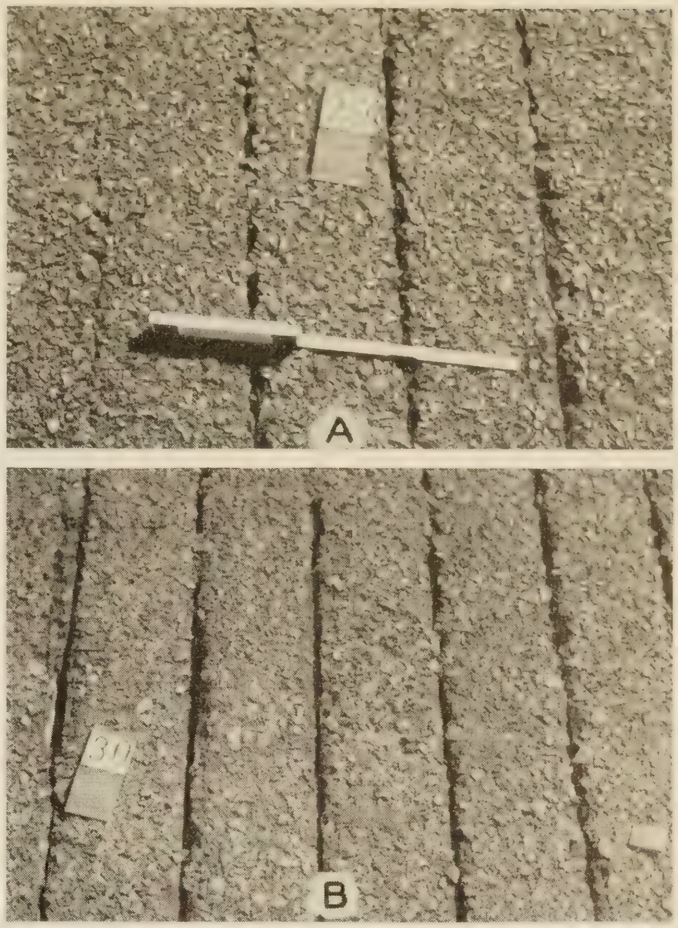


Figure 10.—(A) On a Bridge Floor With Loose Planks the Fabric Broke Quickly. (B) The Condition of This Surface on a Similar Bridge Is Due to the Excellent Bond With the Planks Rather Than the Absence of Fabric.

Raveling occurred in some instances to such an extent that entire planks became uncovered. A number of these had decayed and had been replaced, and at the time the photograph was taken 8 or 10 planks were uncovered and rotten.

No useful purpose appeared to be served by the fabric on bridges that were not rigid or not in good condition when surfaced. The cooperative experimental road in North Carolina included three small wooden bridges which were located a short distance apart and were subjected to identical service conditions. Before the bituminous mat was laid fabric was placed on two of the bridges but not on the third one. The surface condition of two of these bridges 16 months after construction is shown by figure 10, A and B. The mat has adhered well to the planks on all three bridges, but when the planks became loose and moved under traffic the mat broke. On the fabric-covered bridges, the fabric broke sharply whenever the mat cracked because of loose planks. More loose planks were observed on the bridge without fabric than on those containing the fabric. No rotten planks were observed on the latter whereas several were seen on the former. Some of the stringers were showing signs of decay but whether this was the cause of the loose planks or was the result of moisture reaching them after the planks loosened and allowed the mat to crack, is not known. In general, however, where the floor appeared to be rigid the mat laid on the fabric was in better condition than where fabric was not used.

One unsatisfactory condition reported as resulting from the use of fabric on wooden bridge floors was the tendency of the bituminous mat to slip during hot weather. In this instance the fabric was nailed to the planks, which were laid on edge to form the floor, and the bituminous surface was then applied. It was reported that the mat containing the fabric moved under traffic in hot weather and had to be retacked.

#### PERFORMANCE OF THE EXPERIMENTAL SECTIONS DISCUSSED

The States cooperating in the experimental study provided reports of the construction, periodic condition reports, and annual maintenance costs. The discussion presented herein and the conclusions drawn from this investigation are based upon all of the reports that were submitted including those of inspections by the author which have been given previously.

Some experimental roads were eliminated within 2 years after construction because of reconstruction, abandonment for relocation, or complete failure. Others lost their experimental value as a result of the practice in some States of re-treating all bituminous surfaces annually or biennially. Obviously, little information could be obtained relative to the effect of fabric in a given experimental road reported to be in excellent condition when such condition was due to a

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re-treatment just applied without any explanation of its need, especially when the surface had been previously reported to be in good condition. However, a number of experiments were maintained for the 5-year period agreed to and were re-treated only to the extent necessary to maintain them in the customary condition of serviceability.

The fact that the information obtained varied in completeness does not prevent evaluation of the merits of the fabric, and consequently the conclusions presented herein are believed justified by the rather considerable amount of information that has been obtained.

On the basis of the combined reports obtained from the States and by personal inspection, the information acquired may be classified substantially as follows.

*Conclusions were not warranted on seven sections.*—On one section construction difficulties and other circumstances made it impossible to evaluate the effect of the fabric.

On one section the fabric was reported to be beneficial in shoulder treatment in contrast to behavior of an adjacent shoulder where fabric was not used. The two areas, however, were of different composition and construction so that comparable conditions did not exist.

On five sections the information submitted was insufficient to permit conclusions.

*Fabric appeared to retard but did not prevent surface failures on eight sections.*—On two of the sections where the fabric was laid on the wooden floors of bridges it was reported that cracking of the bituminous wearing surface was confined to the plank joints; that the bituminous mat did not ravel; and that the mat, in conjunction with the fabric, continued to prevent surface water from reaching the wooden floor. On adjacent bridges without fabric the mat cracked, raveled, and permitted water to eventually rot the floor plank.

On five road sections it was reported that the fabric, although not preventing the development of cracks, did hold the mat together and delay raveling.

On one section where fabric was placed on the road shoulders, some protection against erosion was reported.

*No difference in service behavior of plain and fabric portions was observed on 109 sections.*—By far the greater number of sections showed no difference in service behavior regardless of the presence or absence of fabric.

Failures resulting from poor base or drainage conditions on a given section were as prevalent on the fabric portions as on those without fabric.

In fact, the locations of the sections containing fabric could not be identified except by means of the section markers.

It was definitely shown that fabric will not prevent surface failures caused by inferior base material, inadequate thickness, faulty construction, frost action, or cracking of bituminous mats; nor will it prevent moisture reaching the base after the surface cracks. No benefit of fabric as an edge reinforcement was apparent. There was no measurable difference in behavior between the different types of fabric.

*Fabric portions were less satisfactory than plain portions on 15 sections.*—On two sections fabric was a definite disadvantage from the standpoint of maintenance which consisted of remixing and re-laying the bituminous mats with blade machines.

On 11 sections the surface mats containing fabric did not adhere to the underlying course but slipped laterally under the action of traffic although the fabric had been nailed in place. In three such instances reported the fabric was used on wooden bridge floors and in eight instances the fabric was used in re-treatments applied to existing bituminous surfaces. On the same sections, slipping of the surface mat did not occur when the fabric was not used.

On two sections the fabric portions were simply reported as less satisfactory than the plain portions.

*Fabric deteriorated in service on the 12 sections where samples were recovered.*—On 12 of the 84 sections personally inspected by the author, samples of the bituminous mats were taken for the recovery and examination of the fabric. Two samples were cut from areas where base and surface failures had occurred and, as might be expected, the fabric had been completely destroyed. All other samples were taken from areas that were in excellent condition and had neither required nor received any maintenance since construction. Without exception the fabric taken from these areas was in very poor condition and in many instances it was practically destroyed. Obviously, the continued good service behavior of the wearing surfaces could not be attributed to the fabric.

## CONSTRUCTION AND MAINTENANCE COSTS

The average cost of the fabric delivered and placed was 7.35 cents per square yard or $862 per mile of 20-foot road. This increase in cost would be a substantial percentage of the cost of constructing surface treatments for which the use of fabric was especially advocated and which represented approximately 70 percent of the sections built in this experimental program.

Reports on the maintenance of the experimental roads were submitted through the States by State maintenance engineers and by the local supervisors who were directly responsible for maintaining them. Maintenance practices vary greatly throughout the country,—even in different parts of a given State,—and these variable practices governed the maintenance of the experimental roads to a large extent. A review of the maintenance-cost data submitted indicates chiefly that there was little difference between the maintenance required for the plain sections and that for the sections containing fabric.

## CONCLUSIONS

This investigation shows that the benefits expected to result from the use of cotton fabric were not obtained.

No benefit of fabric as an edge reinforcement was apparent. Edge failures are not as prevalent now as formerly and at present they are caused chiefly by unsatisfactory base conditions.

The assumption that the fabric, when impregnated with asphalt or tar, would serve as a waterproof membrane to prevent surface moisture reaching the base did not prove correct as the fabric deteriorated even when surface and base failures did not occur.

Since failures resulting from inadequate base support were as prevalent on sections containing fabric as on those in which fabric was not used, it cannot be said that cotton fabric would compensate for inadequate base support or permit the construction of cheaper bases.

Under certain conditions, as stated herein, cotton fabric was beneficial when used on wooden bridge floors.

The use of cotton fabric in the types of construction employed in these experiments results in a material increase in the cost of construction. It has little or no practical value and consequently the increased cost is not warranted. When used on bridge floors the increased cost may or may not be warranted depending upon the condition of the structure.

# TRENDS IN MOTOR-VEHICLE TRAVEL, 1936 TO 1945[1]

BY THE DIVISION OF FINANCIAL AND ADMINISTRATIVE RESEARCH, PUBLIC ROADS ADMINISTRATION

Reported by G. P. ST. CLAIR, Chief of Division

IN ORDER TO MEET THE DEMAND for information on the subject, classified estimates of motor-vehicle travel in the United States during the past 10 years have been prepared, with the aid of data obtained in cooperative studies by the State highway departments and the Public Roads Administration. The results of these estimates are given in tables 1 to 5.

Table 1 gives the estimates of rural, urban, and total vehicle-miles traveled, in each year from 1936 to 1945, by passenger cars, commercial busses, school and nonrevenue busses, and trucks and combinations. In table 2 are given the numbers of motor vehicles registered annually during the 10-year period, as adjusted for the computation of vehicle-miles. Table 3 gives the travel estimates in terms of annual miles per vehicle. Total motor-fuel consumption classified by type of vehicle is given in table 4, and rates of motor-fuel consumption in miles per gallon are given in table 5.

[1] The data reported in this article are for all rural and urban roads, but exclude military traffic for the years 1942 to 1945. In the article Traffic Trends on Rural Roads in 1945, which appears on page 268 of this issue of PUBLIC ROADS, the travel data reported are for all rural roads and include military traffic; and the data reported as obtained from the summer loadometer surveys are for the 345,000 miles of main rural roads only.

#### TRENDS IN MOTOR-VEHICLE TRAVEL GREATLY AFFECTED BY WARTIME RESTRICTIONS

The trends in motor-vehicle travel during this 10-year period are illustrated in figures 1, 2, and 3. Figure 1 shows, in line-diagram form, the variation from year to year in the volume of travel—rural, urban, and total—of all motor vehicles taken as a group. Figure 2 shows by similar diagrams the annual variations in rural, urban, and total travel of passenger cars and of trucks and combinations. Annual averages in miles per vehicle are given in figure 3.

The general characteristics of the trends illustrated in these tables and diagrams have been reported by the Public Roads Administration in monthly statements to highway magazines during the past few years. During the years from 1936 to 1941 the trend in motor-vehicle travel was generally upward, culminating in the latter year in a very substantial increase over the levels reached in 1940. Shortly after the outbreak of war the cessation of civilian motor-vehicle production, the rationing of tires, and finally gasoline rationing turned the trend of traffic sharply downward. This

TABLE 1.—*Classified estimate of travel by motor vehicles, 1936 to 1945*

| Item | Travel in each calendar year in million vehicle-miles | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1936 | 1937 | 1938 | 1939 | 1940 | 1941 | 1942 [1] | 1943 [1] | 1944 [1] | 1945 [1] |
| Passenger cars (including taxicabs): | | | | | | | | | | |
| Rural travel | 99, 327 | 106, 399 | 107, 786 | 113, 980 | 120, 499 | 133, 891 | 100, 107 | 71, 510 | 74, 321 | 90, 131 |
| Urban travel | 109, 327 | 117, 068 | 116. 388 | 121, 649 | 129, 060 | 141, 794 | 118, 132 | 90, 278 | 91, 752 | 109, 054 |
| Total | 208, 654 | 223, 467 | 224, 174 | 235, 629 | 249, 559 | 275, 685 | 218, 239 | 161, 788 | 166, 073 | 199, 185 |
| Commercial busses: | | | | | | | | | | |
| Rural travel | 733 | 771 | 771 | 771 | 808 | 878 | 1, 036 | 1, 139 | 1, 327 | 1, 326 |
| Urban travel | 1, 031 | 1, 083 | 1, 083 | 1, 085 | 1, 136 | 1, 234 | 1, 456 | 1, 601 | 1, 866 | 1, 864 |
| Total | 1, 764 | 1, 854 | 1, 854 | 1, 856 | 1, 944 | 2, 112 | 2, 492 | 2, 740 | 3, 193 | 3, 190 |
| School and nonrevenue busses: | | | | | | | | | | |
| Rural travel | 542 | 573 | 588 | 627 | 640 | 635 | 573 | 562 | 545 | 577 |
| Urban travel | 61 | 65 | 66 | 71 | 73 | 73 | 65 | 63 | 61 | 65 |
| Total | 603 | 638 | 654 | 698 | 713 | 708 | 638 | 625 | 606 | 642 |
| All busses: | | | | | | | | | | |
| Rural travel | 1. 275 | 1, 344 | 1, 359 | 1, 398 | 1, 448 | 1, 513 | 1, 609 | 1, 701 | 1. 872 | 1, 903 |
| Urban travel | 1, 092 | 1, 148 | 1, 149 | 1, 156 | 1. 209 | 1, 307 | 1, 521 | 1, 664 | 1, 927 | 1, 929 |
| Total | 2, 367 | 2, 492 | 2, 508 | 2, 554 | 2, 657 | 2, 820 | 3, 130 | 3, 365 | 3, 799 | 3, 832 |
| All passenger vehicles: | | | | | | | | | | |
| Rural travel | 100, 602 | 107, 743 | 109, 145 | 115, 378 | 121, 947 | 135, 404 | 101, 716 | 73, 211 | 76, 193 | 92, 034 |
| Urban travel | 110, 419 | 118, 216 | 117, 537 | 122, 805 | 130, 269 | 143, 101 | 119, 653 | 91, 942 | 93, 679 | 110, 983 |
| Total | 211, 021 | 225, 959 | 226, 682 | 238, 183 | 252, 216 | 278, 505 | 221, 369 | 165, 153 | 169, 872 | 203, 017 |
| Trucks and combinations: | | | | | | | | | | |
| Rural travel | 22, 076 | 24, 295 | 25, 768 | 27, 771 | 30, 203 | 34, 401 | 27, 145 | 24, 546 | 24, 637 | 27, 149 |
| Urban travel | 19, 031 | 19, 856 | 18, 727 | 19, 448 | 19, 724 | 20, 490 | 18, 582 | 17, 048 | 17, 071 | 18, 760 |
| Total | 41, 107 | 44, 151 | 44, 495 | 47, 219 | 49, 927 | 54, 891 | 45, 727 | 41, 594 | 41, 708 | 45, 909 |
| All motor vehicles: | | | | | | | | | | |
| Rural travel | 122, 678 | 132, 038 | 134, 913 | 143, 149 | 152, 150 | 169, 805 | 128, 861 | 97, 757 | 100, 830 | 119, 183 |
| Urban travel | 129, 450 | 138, 072 | 136, 264 | 142, 253 | 149, 993 | 163, 591 | 138, 235 | 108, 990 | 110, 750 | 129, 743 |
| Total | 252, 128 | 270, 110 | 271, 177 | 285, 402 | 302, 143 | 333, 396 | 267, 096 | 206, 747 | 211, 580 | 248, 926 |

[1] For years subsequent to 1941, figures do not include travel of vehicles owned by the military services. Data for 1945 are preliminary, subject to revision.

Table 2.—*Numbers of motor vehicles registered 1936 to 1945 as adjusted for vehicle-mile estimates* [1]

| Calendar year | Passenger vehicles | | | | | Trucks and combinations | All motor vehicles |
|---|---|---|---|---|---|---|---|
| | Passenger cars, including taxicabs | Busses | | | All passenger vehicles | | |
| | | Commercial | School and nonrevenue | Total | | | |
| | *1,000 vehicles* | *1,000 vehicles* | *1,000 vehicles* | *1,000 vehicles* | *1,000 vehicles* | *1,000 vehicles* | *1,000 vehicles* |
| 1936 | 24, 201 | 49 | 75 | 124 | 24, 325 | 4, 071 | 28, 396 |
| 1937 | 25, 490 | 51 | 80 | 131 | 25, 621 | 4, 301 | 29, 922 |
| 1938 | 25, 272 | 51 | 82 | 133 | 25, 405 | 4, 285 | 29, 690 |
| 1939 | 26, 252 | 52 | 87 | 139 | 26, 391 | 4, 495 | 30, 886 |
| 1940 | 27, 488 | 54 | 89 | 143 | 27, 631 | 4, 699 | 32, 330 |
| 1941 | 29, 691 | 59 | 88 | 147 | 29, 838 | 5, 112 | 34, 950 |
| 1942 | 27, 970 | 69 | 80 | 149 | 28, 119 | 4, 762 | 32, 881 |
| 1943 | 26, 005 | 76 | 78 | 154 | 26, 159 | 4, 611 | 30, 770 |
| 1944 | 25, 562 | 80 | 76 | 156 | 25, 718 | 4, 642 | 30, 360 |
| 1945 | 25, 789 | 83 | 80 | 163 | 25, 952 | 4, 956 | 30, 908 |

[1] These registration totals differ from those given in the annual Public Roads statistical table MV-1, State Motor-Vehicle Registrations, because of numerous adjustments, chief among which are the following: (1) Inclusion of publicly owned vehicles, which are listed separately in statistical table MV-1; (2) substitution of bus totals as given by the bus industry; and (3) reduction of truck registrations by 2.5 percent to allow for trucks registered in more than one State. For years subsequent to 1941 vehicles owned by the military services are not included.

trend reached its lowest ebb in 1943, when total motor-vehicle travel, amounting to approximately 207 billion vehicle-miles, was only 62 percent of the total in 1941. Although gasoline shortages were somewhat eased in 1944, there was only a slight increase in traffic volume.

With the end of the war in August 1945, the pent-up demand for motor-vehicle travel was in large part released, in spite of continued tire shortages and the scarcity of new passenger cars. Traffic volume surged upward, with the result that 1945 travel, amounting to approximately 249 billion vehicle-miles, was nearly 18 percent above the 1944 level, and about 75 percent of

Table 3.—*Estimate of average miles per vehicle traveled by motor vehicles of different types in calendar years 1936 to 1945*

| Calendar year | Passenger vehicles | | | | | Trucks and combinations | All motor vehicles |
|---|---|---|---|---|---|---|---|
| | Passenger cars, including taxicabs | Busses | | | All passenger vehicles | | |
| | | Commercial | School and nonrevenue | All busses | | | |
| | *Miles* | *Miles* | *Miles* | *Miles* | *Miles* | *Miles* | *Miles* |
| 1936 | 8, 622 | 36, 000 | 8, 000 | 19, 033 | 8, 675 | 10, 098 | 8, 879 |
| 1937 | 8, 767 | 36, 000 | 8, 000 | 18, 991 | 8, 819 | 10, 264 | 9, 027 |
| 1938 | 8, 871 | 36, 000 | 8, 000 | 18, 822 | 8, 923 | 10, 383 | 9, 134 |
| 1939 | 8, 976 | 36, 000 | 8, 000 | 18, 392 | 9, 025 | 10, 504 | 9, 240 |
| 1940 | 9, 079 | 36, 000 | 8, 000 | 18, 562 | 9, 128 | 10, 624 | 9, 346 |
| 1941 | 9, 285 | 36, 000 | 7, 980 | 19, 134 | 9, 334 | 10, 739 | 9, 539 |
| 1942 | 7, 803 | 36, 000 | 7, 989 | 20, 993 | 7, 873 | 9, 602 | 8, 123 |
| 1943 | 6, 221 | 36, 000 | 7, 994 | 21, 809 | 6, 313 | 9, 021 | 6, 719 |
| 1944 | 6, 497 | 40, 000 | 7, 990 | 24, 401 | 6, 605 | 8, 984 | 6, 969 |
| 1945 [1] | 7, 724 | 38, 500 | 7, 992 | 23, 489 | 7, 823 | 9, 264 | 8, 054 |

[1] Preliminary estimate, subject to revision.

the volume in 1941. This upward trend has continued strongly during recent months.

The major objective of wartime travel restrictions was directed toward reduction in the travel of passenger cars. The effect of this policy can be perceived readily in figure 2. The total volume of passenger-car travel was reduced from 276 billion vehicle-miles in 1941 to 162 billion in 1943, a drop of 41 percent; whereas the travel of trucks and combinations declined only 24 percent, from 55 billion in 1941 to 42 billion in 1943. The volume of travel of commercial busses increased substantially during the war period.

The same trends are shown in figure 3 in which comparisons are given in terms of miles per vehicle. The estimated average annual mileage of passenger cars dropped from 9,285 miles in 1941 to 6,221 in 1943 and recovered to 7,724 in 1945. The drop in average an-


Figure 1.—Estimated Travel of All Motor Vehicles in Calendar Years 1936 to 1945.

Table 4.—*Estimate of motor-fuel consumption by motor vehicles of different types in calendar years 1936 to 1945*

[In million gallons]

| Calendar year | Passenger vehicles | | | | | Trucks and combinations | All motor vehicles [1] |
|---|---|---|---|---|---|---|---|
| | Passenger cars, including taxicabs | Busses | | | All passenger vehicles | | |
| | | Commercial | School and nonrevenue | Total | | | |
| 1936 | 13,648 | 320 | 58 | 378 | 14,026 | 4,003 | 18,029 |
| 1937 | 14,617 | 340 | 61 | 401 | 15,018 | 4,365 | 19,383 |
| 1938 | 14,663 | 343 | 63 | 406 | 15,069 | 4,465 | 19,534 |
| 1939 | 15,412 | 347 | 67 | 414 | 15,826 | 4,807 | 20,633 |
| 1940 | 16,323 | 367 | 69 | 436 | 16,759 | 5,156 | 21,915 |
| 1941 | 18,031 | 402 | 69 | 471 | 18,502 | 5,754 | 24,256 |
| 1942 | 14,428 | 484 | 62 | 546 | 14,974 | 4,889 | 19,863 |
| 1943 | 10,821 | 543 | 60 | 603 | 11,424 | 4,534 | 15,958 |
| 1944 | 11,108 | 639 | 58 | 697 | 11,805 | 4,576 | 16,381 |
| 1945 [2] | 13,323 | 638 | 62 | 700 | 14,023 | 5,055 | 19,078 |

[1] These totals differ by small amounts from the totals of highway use of motor fuel given in the annual Public Roads statistical table G–21, Analysis of Motor-Fuel Usage, chiefly because of an allowance for use in motorcycles.
[2] Preliminary estimate, subject to revision.

nual mileage of trucks and combinations was much more moderate. From a prewar maximum of 10,739 miles in 1941 this average was reduced to 9,021 in 1943 and recovered to 9,264 in 1945.

A comparison of the diagrams given in figure 2 makes it very evident that wartime restrictions had a much greater effect on rural travel than on urban travel. The travel of passenger cars on rural roads in 1943 dropped 47 percent below the 1941 level; whereas their urban travel dropped only 36 percent. Similarly the decline in the rural travel of trucks and combinations was 29 percent, as against a decline of 17 percent in urban travel.

Table 5.—*Estimate of average miles traveled, per gallon of motor fuel consumed, by motor vehicles of different types in calendar years 1936 to 1945*

[Miles per gallon]

| Calendar year | Passenger vehicles | | | | | Trucks and combinations | All motor vehicles |
|---|---|---|---|---|---|---|---|
| | Passenger cars, including taxicabs | Busses | | | All passenger vehicles | | |
| | | Commercial | School and nonrevenue | All busses | | | |
| 1936 | 15.29 | 5.50 | 10.38 | 6.25 | 15.04 | 10.27 | 13.98 |
| 1937 | 15.29 | 5.45 | 10.38 | 6.20 | 15.05 | 10.12 | 13.94 |
| 1938 | 15.29 | 5.40 | 10.38 | 6.17 | 15.04 | 9.97 | 13.88 |
| 1939 | 15.29 | 5.35 | 10.38 | 6.17 | 15.05 | 9.82 | 13.83 |
| 1940 | 15.29 | 5.30 | 10.37 | 6.10 | 15.05 | 9.68 | 13.79 |
| 1941 | 15.29 | 5.25 | 10.36 | 5.99 | 15.05 | 9.54 | 13.75 |
| 1942 | 15.13 | 5.15 | 10.37 | 5.74 | 14.78 | 9.35 | 13.45 |
| 1943 | 14.95 | 5.05 | 10.39 | 5.58 | 14.46 | 9.18 | 12.96 |
| 1944 | 14.95 | 5.00 | 10.39 | 5.45 | 14.39 | 9.12 | 12.92 |
| 1945 [1] | 14.95 | 5.00 | 10.39 | 5.48 | 14.48 | 9.08 | 13.05 |

[1] Preliminary estimate, subject to revision.

## PROCEDURES USED IN ESTIMATING MOTOR-VEHICLE TRAVEL

In planning this analysis it was recognized that rigorous accuracy could not be achieved, and that estimates for the years since 1941 would be particularly vulnerable because the relative amounts of travel by different types of vehicles were profoundly altered during the war by gasoline rationing and other wartime restrictions and shortages. The data available from numerous sources, although gratifyingly consistent in general trends and relations, exhibit inconsistencies in detail which are the result of the variable margins of error surrounding all highway statistics. The values given in tables 1 to 5 represent a compromise solution

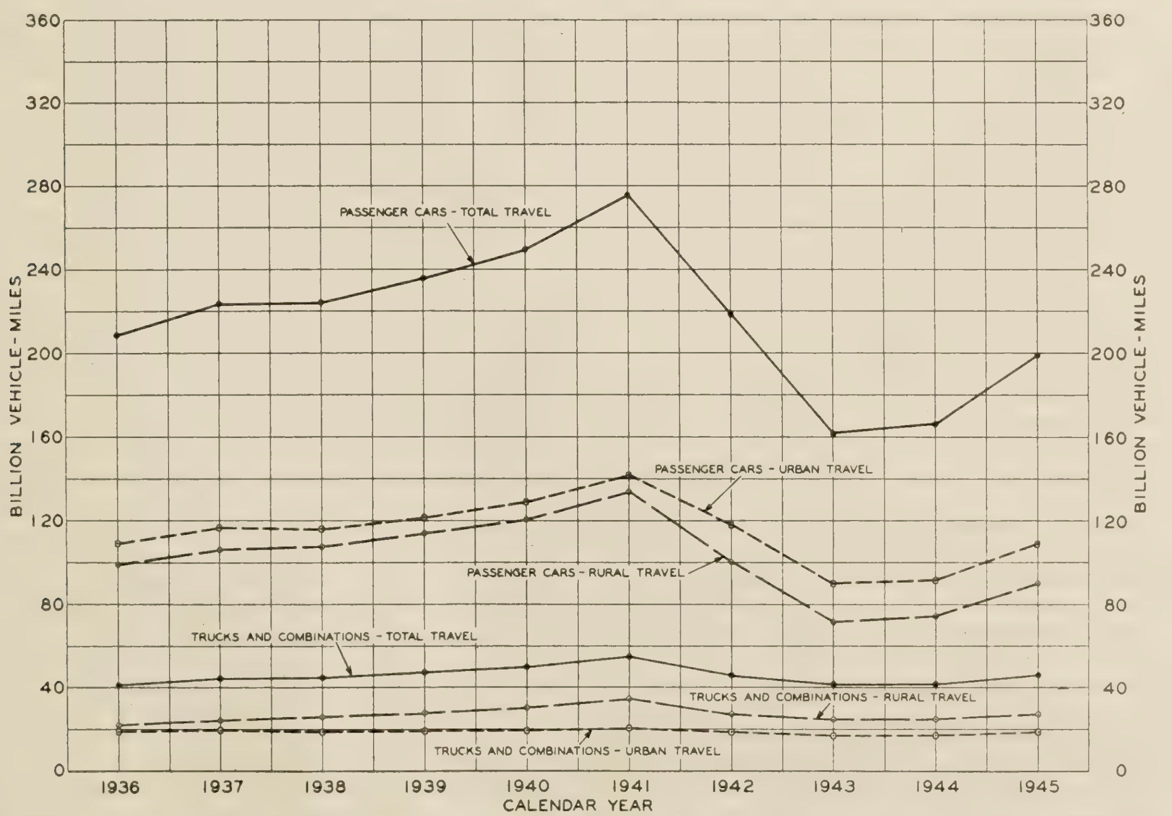


Figure 2.—Estimated Travel of Passenger Cars and of Trucks and Combinations in Calendar Years 1936 to 1945.

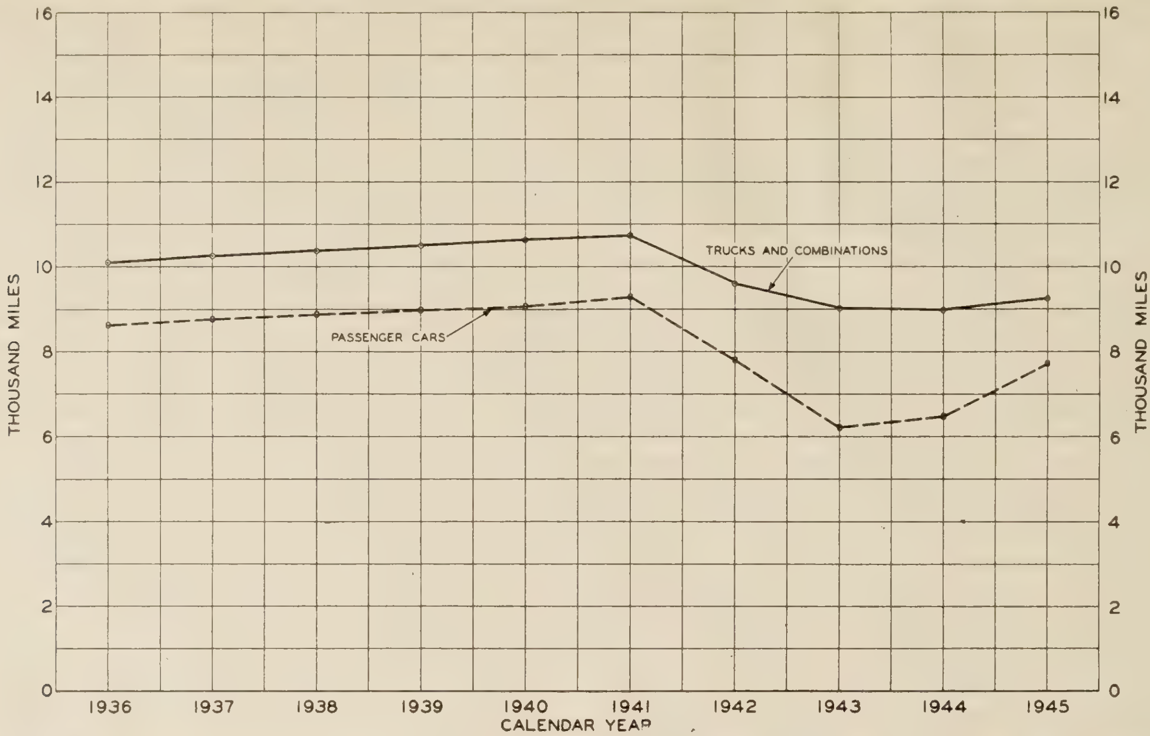


FIGURE 3.—ESTIMATED AVERAGE MILES PER VEHICLE TRAVELED BY PASSENGER CARS AND BY TRUCKS AND COMBINATIONS IN CALENDAR YEARS 1936 TO 1945.

in which conflicts in the basic data were resolved, sometimes by averaging and sometimes by the exercise of judgment. Some of the principal features of the analysis are described in the following paragraphs.

*Basic Sources of Data.*—Data regarding the volumes of travel by motor vehicles of different types are obtainable from four major types of study which the Public Roads Administration and the planning surveys of the State highway departments have conducted during recent years. These are the traffic surveys, the motor-vehicle-allocation surveys, the road-use surveys, and the truck and bus inventory.

The comprehensive basic surveys of rural-road traffic, covering a single year, were conducted in most States during the period from 1935 to 1939. For any individual State, estimates for years since that of the comprehensive survey are made on a comparative basis by means of the continuous record of automatic recorder stations, supplemented by whatever classification counts the State has made, including the annual summer counts in which data on vehicle loads are also obtained. The results of these continuous studies, which have been published by the Public Roads Administration in Wartime Changes in the Volume and Composition of Traffic on Rural Roads in the United States (1942, 1943, 1944), yield among other things Nation-wide estimates of the total volume of rural-road traffic classified as between "Trucks and Combinations" and "Other", the latter in effect being passenger vehicles.

The motor-vehicle-allocation studies, which also were 1-year studies, conducted in most States during the period from 1935 to 1939, were originally designed as an adjunct to the planning-survey fiscal studies for the purpose of determining the incidence of motor-vehicle taxation with respect to vehicle type and situs of ownership (rural, urban, and size of urban place). In order to evaluate gasoline-tax payments the respondents, representing a sample of the motor-vehicle population, were asked to report actual or estimated miles driven and average miles per gallon during the previous year. A byproduct of the sample expansion was an estimate of the total miles driven by vehicles registered in the State during the year under study.

The road-use surveys also were designed as adjuncts of the fiscal studies with the objective of determining the incidence of benefit of highway expenditures with respect to vehicle type and situs of ownership. These were interview studies in which the respondents, representing a sample of the motor-vehicle population, were asked to report actual or estimated miles traveled during the previous year, and to account for this driving by describing customary trips, such as home-to-work driving; unusual trips, such as vacation driving; and incidental pleasure and business driving. With the aid of highway maps carried by the interviewers, the trips thus described were subdivided into travel on primary rural roads, secondary and local rural roads, city streets, and "out-of-State." The result was an estimate of the respondent's travel during the year subdivided by class of road or street on which the travel was performed. Other classifications obtained, such as trip length and purpose of travel, are not germane to this discussion. Expansion of the sample led to an approximate evaluation of total travel by vehicles registered in the State during the year under study, classified by type of vehicle and class of road.

From the above description it is evident that the traffic studies produce estimates of rural travel classified by vehicle type, the motor-vehicle-allocation studies produce estimates of total travel classified by vehicle type, and the road-use studies produce estimates of total travel subject to both rural-urban and vehicle-type classifications. As might be expected, the results of these three independent studies, all of them founded on sampling techniques, were not entirely consistent in any individual State or in Nation-wide totals developed from the State figures.

In connection with the preparation of table 1, a calculation was made to determine the relative magnitudes of the changes which would be made, (1) in the volume and distribution of rural travel given by the traffic studies and (2) in the volume and distribution of total travel given by the motor-vehicle-allocation studies, if each were forced to meet "halfway" the rural-urban distribution given by the road-use studies. This comparison was made for the year 1936 which was the year covered by the greatest number of planning survey studies. The percentage changes indicated by this calculation were as follows:

| | Traffic data (rural) | Motor-vehicle-allocation data (total) |
|---|---|---|
| Passenger vehicles | +1. 31 | −3. 03 |
| Trucks and combinations | +5. 15 | +3. 29 |
| All motor vehicles | +2. 00 | −2. 00 |

It was evident that, so far as Nation-wide totals are concerned, a mutual adjustment of the results of all three studies could be made without doing great violence to any of them. In the calculations underlying table 1 it was decided to adopt the following procedure: (1) To accept unchanged the data on rural-road travel given by the traffic studies; (2) to evaluate the distribution of total travel on the basis of the motor-vehicle-allocation studies (urban travel resulting as the difference between the two); and (3) to use road-use data only in auxiliary computations and as a check on the consistency of the results.

One factor leading to this decision was that the elaborate process of reconciliation could thereby be eliminated. Furthermore, a reconciliation which would be acceptable to all concerned with the three studies would have to be made on a State-by-State basis, necessitating a tremendous volume of work. The most compelling reason, however, for accepting the traffic data unchanged is that the automatic recorder data and periodic classification counts afford a means of determining the trends in recent years, whereas there is no corresponding series of periodic data whereby the rural-urban distribution given by the road-use surveys could be corrected for changes since the time when they were made.

The data given by the truck and bus inventory, which are characteristic of the year 1940-41, were used to check the consistency of the calculations, and also for certain auxiliary computations. The annual published data on motor-vehicle registration and gasoline consumption were used as a means of carrying forward the estimates of total travel from the basic year, 1936, to the final year, 1945.

*Motor-Vehicle Registrations.*—In preparation for the evaluation of vehicle-miles a number of adjustments were made in the motor-vehicle registration statistics published in the annual Public Roads table MV–1. Certain inconsistencies in the figures reported by individual States, such as the failure to segregate trailers from trucks or the inclusion of light trucks with passenger cars, were corrected by means of approximations based on data from planning survey studies or other sources. In the case of busses, the annual motor-vehicle statistics do not provide a complete segregation of commercial busses from school and other nonrevenue busses. For this reason the bus totals given in the Public Roads tables were replaced by the totals reported by the bus industry modified only by adding the small number of busses reported as owned by the Federal Government. In the case of trucks and combinations it was thought that a reduction in the reported totals should be made in order to allow for vehicles of this type registered in more than one State. A reduction factor of 2.5 percent, based on data obtained in the truck and bus inventory, was adopted. The adjusted registration totals as given in table 2 include publicly owned vehicles—Federal, State, and local. For years subsequent to 1941, vehicles owned by the military services are not included.

*Busses and Federal Vehicles.*—In order to simplify the calculations, estimates for busses and for motor vehicles owned by the Federal Government were made separately from the prorating computations (discussed in a later section) by means of which year-to-year estimates of passenger-car and truck travel were made.

In order to estimate the vehicle-miles traveled and motor fuel consumed by busses, it was necessary to determine reasonable average values of annual mileage and miles per gallon. Comparisons were made of data regarding busses given by the motor-vehicle-allocation studies, the truck and bus inventory, and the statistics of the bus industry. No consistent trend in the annual mileage of busses was observed in any of the data available. The values of 36,000 miles per year for commercial busses and 8,000 miles per year for school and nonrevenue busses were, however, found to be reasonably consistent with all the sources, and these values were used for the years 1936 through 1943. Bus industry figures indicated greater annual mileages for commercial busses in 1944 and 1945. The 1944 estimate was set at 40,000 miles and the preliminary estimate for 1945 at 38,500. The estimate of 8,000 miles for school and nonrevenue busses was carried unchanged through 1945.

For 22 States reporting data for commercial busses separately in the motor-vehicle-allocation studies the weighted average per gallon for in-State travel was 5.9 miles. The magazine Bus Transportation publishes each year a report of the total revenue-miles and the total gasoline consumption of common-carrier regular-route operators. Miles per gallon computed from these figures for a number of years were found to vary from 4.4 to 4.6, with some indication of a downward trend. By making an approximate allowance for nonrevenue mileage and taking account of the mileage and gasoline consumption of other commercial busses, estimates were made which varied from 5.38 miles per gallon in 1937 to 5.04 in 1943. After comparison of these figures with the motor-vehicle-allocation data, it was decided to use for commercial busses the series given in table 5 which varies from 5.50 miles per gallon in 1936 to 5.00 miles in 1944 and 1945. This downward trend finds confirmation in bus-industry figures, which indicate a very great increase in the numbers of revenue passengers per bus during this 10-year period.

In the case of school and nonrevenue busses the average of 10.4 miles per gallon given by the motor-vehicle-allocation studies was used for all years.

The computations for Federally owned vehicles, which contribute a negligible part of the total travel, were based largely on the findings regarding annual mileage and miles per gallon resulting from the reports made by all Federal agencies in recent years on the operation of vehicles owned by them. The inclusion in the assembled totals of data computed separately for Federal vehicles has the effect of altering slightly some of the basic averages of annual mileage and miles per gallon used in the calculations for vehicles other than Federal.

*Miles Per Gallon for Passenger Cars and Trucks.*—The weighted average miles per gallon given by the motor-vehicle-allocation studies were 15.575 for passenger cars and 10.511 for trucks and combinations. These values have been regarded by numerous critics as somewhat too high, largely on the ground that any bias in an individual's estimate of miles per gallon is likely to be on the high side. It is also true that data for heavy trucks, including combinations, were rather meager and somewhat erratic. In making compromises to reconcile data from various sources the following modified values were determined for the year 1936:

| | *Miles per gallon* | *Percentage change* |
|---|---|---|
| Passenger cars | 15. 288 | −1. 88 |
| Trucks and combinations | 10. 256 | −2. 49 |

For passenger cars this value was held constant through 1941, but the values for the years thereafter were reduced slightly to allow for the higher percentage of urban driving and reduced efficiency of operation resulting from gasoline rationing and other wartime conditions. The values taken for 1942 and for subsequent years were 15.125 and 14.950, respectively.

For trucks and combinations a correction was introduced to allow for the very substantial increases in average loads observed in loadometer studies made in recent years. From data in the Wartime Changes bulletins, estimates were made of the percentage increases in average operating gross weight between 1936 and 1943. Since the loadometer studies were made on main rural highways, it was estimated that the percentage changes applicable to all roads and streets were two-thirds as great as those indicated by the loadometer studies. The corresponding changes in miles per gallon were obtained by reference to an approximate relation between average operating gross weight and miles per gallon developed in a previous study. This relation, based on a correlation between motor-vehicle-allocation and loadometer data in a number of States, is expressed by the equation:

$$g=0.001137\,W^{0.50177}$$

Where $g$=gallons per mile, and
$W$=average operating gross weight in pounds

Although this equation is based on the analysis of a very limited amount of data, it was considered sufficiently accurate for use in estimating the changes in average miles per gallon of trucks and combinations since the base year, 1936. The final values obtained by this means were as follows:

| | | | |
|---|---|---|---|
| 1936 | 10. 256 | 1941 | 9. 494 |
| 1937 | 10. 100 | 1942 | 9. 334 |
| 1938 | 9. 946 | 1943 | 9. 165 |
| 1939 | 9. 800 | 1944 | 9. 107 |
| 1940 | 9. 654 | 1945 | 9. 075 |

The slight differences between the values given above and those listed for trucks and combinations in table 5 resulted from the inclusion of data for Federal vehicles in the final calculation of averages.

*Vehicle-mile Computations, Passenger Cars and Trucks.*—The prorating procedure by means of which vehicle-miles were evaluated year by year from 1936 through 1941 for the two major vehicle types, passenger cars and trucks and combinations, was as follows:

TABLE 6.—*Comparison of rural travel in the years 1941 to 1943*

| Type of vehicle | Rural travel | | | Comparison by years | | |
|---|---|---|---|---|---|---|
| | 1941 | 1942 | 1943 | 1942/41 | 1943/41 | 1943/42 |
| | *Million vehicle-miles* | *Million vehicle-miles* | *Million vehicle-miles* | *Percent* | *Percent* | *Percent* |
| Passenger vehicles | 135, 404 | 101, 716 | 73, 211 | 75. 12 | 54. 07 | 71. 78 |
| Trucks and combinations | 34, 401 | 27, 145 | 24, 546 | 78. 91 | 71. 35 | 90. 43 |
| Total | 169, 805 | 128, 861 | 97, 757 | 75. 89 | 57. 57 | 75. 86 |

(1) The net gasoline consumption by passenger cars and trucks as a group was determined for each year by deducting the amounts consumed by Federal vehicles and busses, computed separately, and a small allowance for motorcycles, from the published annual totals of highway use (Public Roads tables G–21 and G–201).

(2) For the year 1936 trial values of gasoline consumption by passenger cars and trucks, respectively, were computed by applying to the registration totals the weighted average values of annual mileage given by the motor-vehicle-allocation studies (8,665.8 for cars and 10,131.0 for trucks) and the adjusted average values of miles per gallon (15.288 for cars and 10.256 for trucks); and these values were added to a trial total.

(3) The trial values of gasoline consumption for passenger cars and trucks, respectively, were adjusted by the factor necessary to make their sum equal the "true" value of gasoline consumption by passenger cars and trucks as determined in (1).

(4) Vehicle-miles were evaluated by multiplying the adjusted values of gasoline consumption by the given values of miles per gallon; and adjusted values of average mileage were determined.

(5) For each subsequent year through 1941 the process was repeated, the trial values of average mileage being the final values determined for the previous year.

The assumption underlying this procedure is that changes in total gasoline consumption not accounted for by changes in the number of registered vehicles (together with the estimated changes in the miles per gallon of trucks) are attributable to proportional increases in the average annual mileages of passenger cars and trucks.

*Procedure Used for 1942 and Subsequent Years.*—It was necessary to devise a different procedure for these years because of the known differences in the relative effects on passenger cars and trucks of gasoline rationing and other wartime restrictions and shortages. These differential effects are illustrated by the rural traffic data shown in table 6.

Among those who follow the trends of traffic movement it is a matter of general agreement, supported by a considerable volume of data, that the wartime effects on urban travel were less severe than on rural travel. Urban holders of A gasoline rations did very little rural driving. Urban and suburban holders of home-to-work rations undoubtedly reduced their rural driving in great measure. With respect to trucks the relative changes were not so clearly indicated, but the evidence of urban toll facilities and a limited amount of urban street data tend to confirm the general impression that urban truck travel did not suffer as great a reduction as did rural truck travel.

Since the data on urban traffic trends were not sufficient either in volume or in geographical distribution to establish reliable Nation-wide averages, it was

TABLE 7.—*Effects on calculation of urban travel of assumptions as to the relation of urban travel to rural travel*

| Conditions | Rural travel | Urban travel | Total travel |
|---|---|---|---|
| 1941 travel ........ million vehicle-miles | 169, 805 | 163, 591 | 333, 396 |
| No change in urban travel (1): | | | |
| 1942 travel ........ million vehicle-miles | 128, 861 | 163, 591 | 292, 452 |
| Relation, 1942/1941 ........ percent | 75. 89 | 100. 00 | 87. 72 |
| Urban change proportional to rural change (2): | | | |
| 1942 travel ........ million vehicle-miles | 128, 861 | 124, 149 | 253, 010 |
| Relation, 1942/1941 ........ percent | 75. 89 | 75. 89 | 75. 89 |
| Urban change one-half of percentage of rural change (3): | | | |
| 1941 travel ........ million vehicle-miles | 128, 861 | 143, 862 | 272, 723 |
| Relation, 1942/1941 ........ percent | 75. 89 | 87. 94 | 81. 80 |
| Urban change two-thirds of percentage of rural change (4): | | | |
| 1942 travel ........ million vehicle-miles | 128, 861 | 137, 302 | 266, 163 |
| Relation, 1942/1941 ........ percent | 75. 89 | 83. 93 | 79. 83 |
| Deviations of estimates (3) and (4) in percentage of lower value | ........ | 4. 8 | 2. 5 |

decided to use the rural traffic data as a guide in making the urban estimates. The procedure, which was applied separately to passenger cars and to trucks and combinations, was that of estimating the year-to-year change in urban travel as a percentage of the corresponding change in rural travel. The possibilities of error in this somewhat arbitrary procedure were held within rather narrow limits by the further requirement that the final estimate of total vehicle-miles for each year should be consistent, in terms of motor-fuel consumption accounted for, with the annual published figures on highway use of motor fuel.

In considering estimates for 1942 one might make various assumptions on the decline in urban travel in percentage of its 1941 value. The outer limits of such an estimate might be taken as (1) no reduction at all in urban travel, and (2) a percentage reduction equal to that of rural travel. More reasonable assumptions of a percentage decline in urban travel would be that it equalled (3) one-half, or (4) two-thirds, of the decline in rural travel. The results of calculations according to such assumptions are shown in table 7.

With respect to total travel in 1942, the difference between the results of the two extreme assumptions (1) and (2) is 39,442 or 15.6 percent of the smaller number. The urban estimates differ by 31.8 percent.

It is apparent that, within the range of the more reasonable assumptions (3) and (4) regarding the relative changes in rural and urban travel, very small deviations in the estimates are to be expected. The margin of error was still further narrowed by evaluating motor-fuel consumption from the assumed vehicle-miles and then applying the prorating process so as to equate to the reported highway use of motor fuel as given in Public Roads statistical table G-21.

In making the estimates for 1942 the following assumptions were used: Urban travel of passenger vehicles experienced two-thirds the percentage reduction from 1941 experienced by their rural travel; and urban travel of trucks and combinations experienced one-half the percentage reduction from 1941 experienced by their rural travel.

This device of predicating the estimates of urban travel upon the estimates of rural travel derived from the traffic studies was carried through for the years 1943, 1944, and 1945, the estimates of urban travel for a given year being based on the changes in rural travel from that of the preceding year.

Although the procedure described above, controlled as it is by the reported total volume of motor-fuel consumption, has produced very reasonable results for a series of 4 years, it cannot be recommended as a means for making continuing annual estimates over an extended period. A more firm basis should be established for estimating the total volume of urban travel.

*Travel of Military Vehicles.*—In the estimates for 1941 and prior years vehicles owned by the military services were included with other publicly owned vehicles, and their travel is therefore included in the estimates given in table 1. For 1942 and subsequent years no information is publicly available regarding either the numbers of military vehicles or the motor fuel consumed by them, and the totals and averages given for these years in tables 1 to 5 are applicable to civilian motor vehicles only.

Since the rural traffic studies on which the estimates of rural-road travel are based involve the counting of all vehicles whether civilian or military, it was necessary in arriving at final estimates of the total travel by civilian vehicles to adjust for the relative numbers of military vehicles observed in the traffic counts.

In the annual summer loadometer and traffic studies made on main rural roads in recent years the following Nation-wide percentages of military vehicles to total vehicles were observed:

| | | | |
|---|---|---|---|
| 1942 | 1. 08706 | 1944 | 1. 44327 |
| 1943 | 1. 92865 | 1945 | 0. 81758 |

The percentages given above were applied to the estimated values of all vehicle-miles on main rural roads,[2] and the resulting estimates of the travel of military vehicles on main rural roads were deducted from the estimated total vehicle-miles on all rural roads. Because of the fact that the data for civilian trucks and combinations are given separately in the rural traffic estimates, this deduction was applicable to the totals for vehicles other than civilian trucks and combinations, the estimates for the latter remaining unchanged. The amounts of these deductions, representing the estimated travel of military vehicles on main rural roads, were:

| | *Million vehicle-miles* | | *Million vehicle-miles* |
|---|---|---|---|
| 1942 | 1, 015 | 1944 | 1, 049 |
| 1943 | 1, 370 | 1945 | 701 |

It might have been preferable to estimate travel of military vehicles on secondary and local roads and on city streets so as to include the travel of all vehicles, civilian and military, in table 1; but the data on which to base such estimates were entirely lacking.

*Revisions of Vehicle-mile Estimates.*—For the years 1936 to 1940 the estimates given in tables 1, 2, and 3 are identical with the estimates previously issued in statistical table VM-1 for 1945. The data for the years 1941 to 1944 have been revised, the most notable change being the adjustment with respect to the travel of military vehicles in the years 1942 to 1945 described in the preceding section. The previously published figures for 1944 were preliminary, and are replaced by revised estimates. Other minor revisions were made in the interest of increased accuracy.

The estimates for 1945 are indicated as preliminary, subject to revision at the time preliminary estimates for 1946 are made. It is believed, however, that no material changes will result from such a revision since most of the data on which the 1945 estimates were based were in final form.

[2] See table 11, page 15, in Wartime Changes in the Volume and Composition of Traffic on Rural Roads in the United States in the year 1944.

# TRAFFIC TRENDS ON RURAL ROADS IN 1945 [1]

BY THE DIVISION OF HIGHWAY TRANSPORT RESEARCH, PUBLIC ROADS ADMINISTRATION

Reported by THOMAS B. DIMMICK, Highway Economist

THE TRAFFIC VOLUME TRENDS reported in this analysis are derived principally from the records received from approximately 625 fixed automatic traffic-recorder stations operated continuously on rural roads in 46 States. Trends concerning the volume and nature of truck traffic and loadings were obtained from the information collected in the summer surveys described in another part of this article. Supplemental counts made by many States yielded valuable information concerning total traffic and the portion of the total that consists of single-unit trucks and of combinations. In the analysis of the data consideration has been given to all available information, but the most reliable of this—that derived from the traffic sample with the most complete coverage—is given preference in this report. Vehicle-mile figures for State systems prepared by the States for current years have been used when available in preference to estimates made by applying trend data to estimates of previous years.

[1] The travel data reported in this article are for all rural roads and include military traffic. The data reported as obtained from the summer loadometer surveys, however, are for the 345,000 miles of main rural roads only. In the article Trends in Motor-Vehicle Travel, 1936 to 1945, which appears on page 261 of this issue of PUBLIC ROADS, the data reported are for all rural and urban roads, but exclude military traffic for the years 1942 to 1945.

### TRAVEL TRENDS ON ALL RURAL ROADS

The seasonal variation of all travel on all rural roads for the years 1940 to 1945, inclusive, is shown in figure 1. Traffic in 1943 and 1944 was reduced to about 60 percent of the prewar level, but in 1945 it gradually increased with the approaching end of hostilities until in September with the termination of gasoline rationing it reached a level not much below that of 1940.

Figure 2 shows the relation of traffic on all rural roads in 1944 and in 1945 to that in corresponding months in 1941. As might be expected, a large increase of traffic

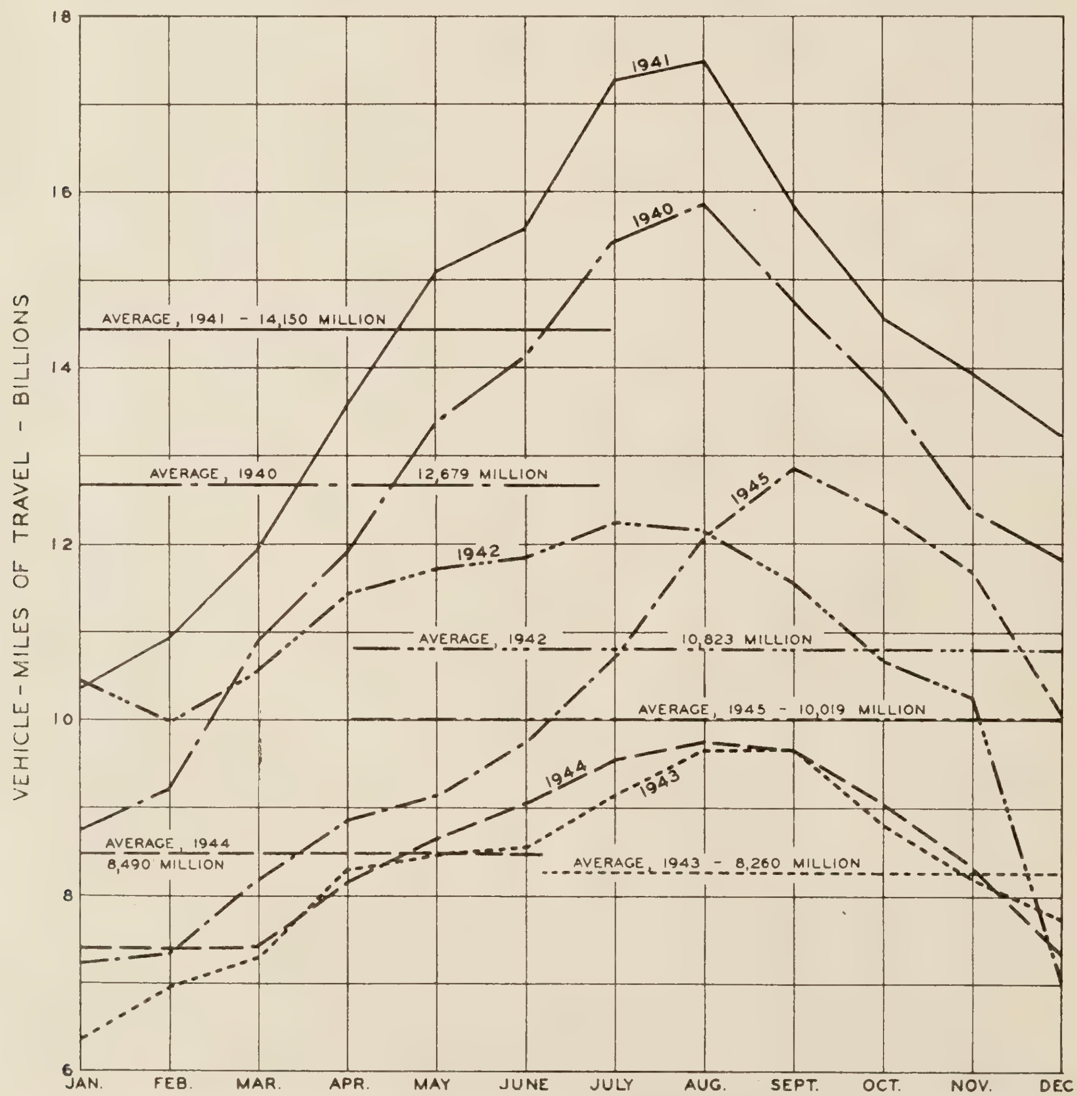


FIGURE 1.—VEHICLE-MILES OF TRAVEL ON ALL RURAL ROADS FROM 1940 TO 1945 BY MONTHS.

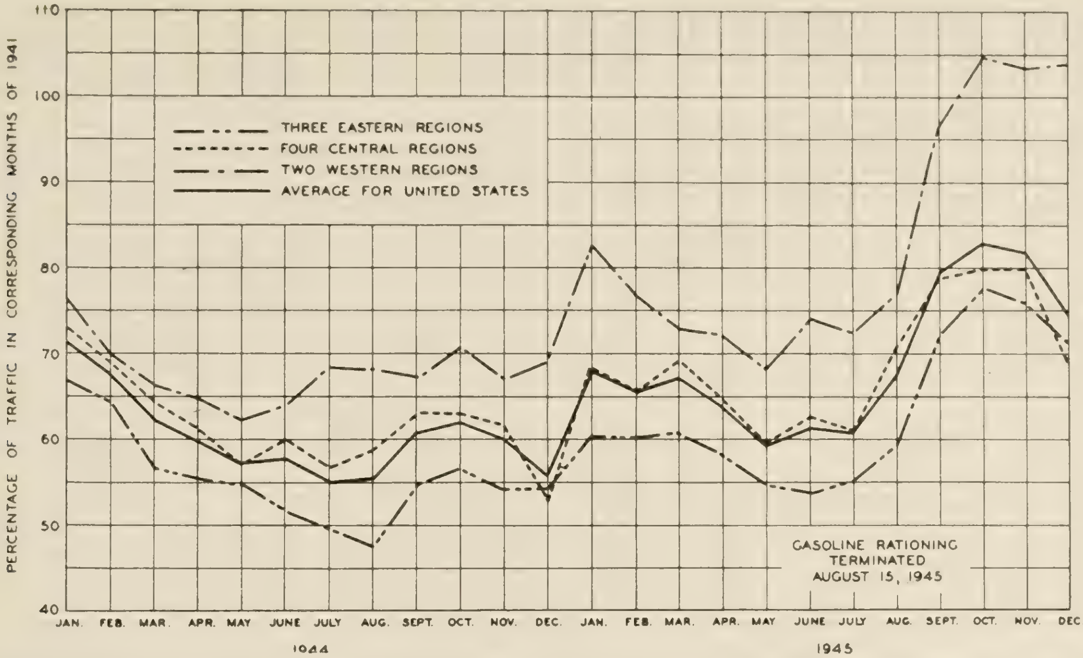


Figure 2.—Relation of Rural Traffic in 1944 and 1945 to That in the Corresponding Months of 1941 Expressed as Percentages.

occurred in all sections of the country as soon as gasoline rationing was terminated. Particularly noteworthy is the increase of traffic in the western regions, where total traffic increased so rapidly that during the last 2 months of 1945 it exceeded the previous all-time levels established in 1941.

Traffic information is analyzed in this report for the United States as a whole, for each census region, and generally for three groups of regions that roughly represent the eastern seaboard, the Central States, and the Western States. The census regions with the States included in each are shown in figure 3. The data available are not deemed sufficient to justify presentation of separate statistics for each State.

The ratio of traffic volume in 1945 to that in corresponding months of 1944 is shown in table 1. The general traffic level in 1945 increased from a point 5 percent below the level of January 1944 to 33 percent above that of December 1944.

In table 2 the 1945 traffic is compared with that in the corresponding months of 1941. The approach to 1941 levels during the latter part of 1945 in all sections of the country, and exceeding this level in the Pacific region, is evident.


Figure 3.—Regions of the United States Based on Groupings of the States by the U. S. Bureau of the Census.

Table 3 shows by census regions the percentage of the year's traffic in each month of the year, for 1945 and for 1941. Of interest is the noticeable shifting of traffic from the Eastern States to the Pacific Coast area that occurred during the period. Only 9.70 percent of the total traffic in the United States occurred in the Pacific region in 1941 whereas in 1945 the percentage for this region increased to 12.13. The percentage for the three eastern regions, on the other hand, decreased from 33.83 percent in 1941 to 30.83 percent in 1945.

#### SUMMER SURVEY MADE ON MAIN RURAL ROADS

During the summer of 1945 a survey was conducted by the highway departments of 37 States in cooperation with the Public Roads Administration to determine the trends in the volume and composition of traffic and in the weights of trucks and truck combinations

Table 1.—*Ratio of traffic volume in 1945 to that in corresponding months of 1944 as determined from automatic traffic-recorder data*

| Region | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eastern regions: | | | | | | | | | | | | |
| New England | 0.86 | 0.88 | 1.01 | 1.03 | 0.97 | 1.10 | 1.14 | 1.31 | 1.41 | 1.38 | 1.36 | 1.23 |
| Middle Atlantic | .84 | .93 | 1.10 | 1.05 | .99 | 1.01 | 1.10 | 1.28 | 1.34 | 1.40 | 1.41 | 1.32 |
| South Atlantic | .97 | .96 | 1.07 | 1.07 | 1.01 | 1.04 | 1.09 | 1.19 | 1.26 | 1.35 | 1.39 | 1.32 |
| Average | .90 | .93 | 1.07 | 1.05 | 1.00 | 1.04 | 1.11 | 1.24 | 1.32 | 1.37 | 1.40 | 1.31 |
| Midwest regions: | | | | | | | | | | | | |
| East North Central | .87 | .93 | 1.09 | 1.05 | 1.01 | 1.02 | 1.06 | 1.22 | 1.25 | 1.28 | 1.29 | 1.34 |
| East South Central | .93 | .94 | 1.03 | 1.02 | 1.06 | 1.05 | 1.14 | 1.26 | 1.26 | 1.27 | 1.34 | 1.31 |
| West North Central | .95 | .98 | 1.14 | 1.09 | 1.05 | 1.08 | 1.04 | 1.17 | 1.29 | 1.28 | 1.25 | 1.19 |
| West South Central | 1.03 | .99 | 1.03 | 1.04 | 1.05 | 1.04 | 1.11 | 1.16 | 1.21 | 1.23 | 1.30 | 1.30 |
| Average | .94 | .96 | 1.08 | 1.05 | 1.04 | 1.04 | 1.07 | 1.20 | 1.25 | 1.27 | 1.29 | 1.29 |
| Western regions: | | | | | | | | | | | | |
| Mountain | 1.08 | 1.08 | 1.09 | 1.09 | 1.12 | 1.13 | 1.16 | 1.24 | 1.32 | 1.38 | 1.37 | 1.33 |
| Pacific | 1.09 | 1.11 | 1.11 | 1.13 | 1.08 | 1.17 | 1.17 | 1.23 | 1.49 | 1.53 | 1.63 | 1.58 |
| Average | 1.09 | 1.10 | 1.10 | 1.12 | 1.10 | 1.16 | 1.17 | 1.23 | 1.43 | 1.47 | 1.54 | 1.50 |
| United States average | .95 | .97 | 1.08 | 1.06 | 1.04 | 1.06 | 1.10 | 1.22 | 1.30 | 1.34 | 1.36 | 1.33 |

TABLE 2.—*Ratio of traffic volume in 1945 to that in corresponding months of 1941 as determined from automatic traffic-recorder data*

| Region | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eastern regions: | | | | | | | | | | | | |
| New England | 0.61 | 0.56 | 0.62 | 0.54 | 0.47 | 0.46 | 0.45 | 0.49 | 0.69 | 0.68 | 0.63 | 0.61 |
| Middle Atlantic | .57 | .59 | .54 | .57 | .51 | .50 | .55 | .60 | .70 | .76 | .73 | .67 |
| South Atlantic | .63 | .62 | .66 | .62 | .62 | .61 | .60 | .64 | .76 | .84 | .83 | .78 |
| Average | .60 | .60 | .61 | .58 | .55 | .54 | .55 | .59 | .72 | .78 | .76 | .71 |
| Midwest regions: | | | | | | | | | | | | |
| East North Central | .61 | .62 | .66 | .57 | .52 | .55 | .54 | .67 | .76 | .73 | .73 | .63 |
| East South Central | .75 | .73 | .78 | .74 | .70 | .73 | .70 | .85 | .84 | .89 | .94 | .71 |
| West North Central | .74 | .65 | .68 | .63 | .59 | .62 | .59 | .64 | .78 | .81 | .74 | .64 |
| West South Central | .71 | .68 | .72 | .75 | .72 | .76 | .74 | .79 | .83 | .86 | .91 | .79 |
| Average | .69 | .66 | .69 | .65 | .60 | .63 | .61 | .71 | .79 | .80 | .80 | .68 |
| Western regions: | | | | | | | | | | | | |
| Mountain | .81 | .76 | .70 | .72 | .68 | .67 | .66 | .74 | .89 | .96 | .89 | .90 |
| Pacific | .84 | .77 | .75 | .72 | .69 | .78 | .76 | .78 | 1.00 | 1.09 | 1.12 | 1.11 |
| Average | .83 | .77 | .73 | .72 | .68 | .74 | .73 | .77 | .96 | 1.05 | 1.03 | 1.04 |
| United States average | .68 | .66 | .67 | .64 | .59 | .61 | .61 | .68 | .79 | .83 | .82 | .74 |

on main rural roads. This survey followed the general plan of similar surveys conducted in 1942, 1943, and 1944. Weighing stations were operated during July, August, or September in all States except Florida, Indiana, Massachusetts, Missouri, Oregon, Ohio, Rhode Island, Utah, Vermont, South Carolina, and Virginia.

During the survey 441 weight stations were operated, all of which had been used in the 1944 survey except 10 in Iowa which had been used in the survey conducted in 1943. The work was so scheduled as to insure maximum comparability with data obtained in the previous years.

Each station was operated for 8 hours on a weekday, either from 6 a. m. to 2 p. m. or from 2 p. m. to 10 p. m. All traffic passing the stations during the period of operation was counted and classified. Military vehicles were separated from civilian traffic and classified into six types. Civilian vehicles were classified as local passenger cars, foreign or out-of-State passenger cars, light single-unit trucks, medium single-unit trucks, heavy single-unit trucks, tractor-truck and semitrailer combinations, truck and trailer combinations, and busses.

During the period of the survey 3,979 military vehicles and 482,702 civilian vehicles were counted. The civilian traffic included 102,598 trucks or 21.3 percent of the total. The survey period, number of stations operated, number of vehicles counted, and number of trucks weighed in each State are shown in table 4.

At stations where traffic volume permitted all trucks and truck combinations were stopped and weighed, but where the volume was so large as to make this procedure impracticable a representative sample was obtained by selecting trucks at random from those which passed. Military vehicles, passenger cars, and

TABLE 3.—*Percentage of total monthly traffic in each United States census region in 1945 and 1941 with ratio between the percentage in 1945 and the percentage in 1941*

| Period | Eastern regions | | | | Midwest regions | | | | | Western regions | | | United States total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | New England | Middle Atlantic | South Atlantic | Total | East North Central | East South Central | West North Central | West South Central | Total | Mountain | Pacific | Total | |
| January: | | | | | | | | | | | | | |
| 1941 | 4.54 | 12.82 | 16.10 | 33.46 | 19.18 | 6.63 | 11.73 | 13.83 | 51.37 | 5.04 | 10.13 | 15.17 | 100 |
| 1945 | 4.05 | 10.75 | 14.94 | 29.74 | 17.19 | 7.36 | 12.82 | 14.39 | 51.76 | 5.99 | 12.51 | 18.50 | 100 |
| 1945:1941 | .89 | .84 | .93 | .89 | .90 | 1.11 | 1.09 | 1.04 | 1.01 | 1.19 | 1.23 | 1.22 | ---------- |
| February: | | | | | | | | | | | | | |
| 1941 | 4.99 | 12.27 | 15.54 | 32.80 | 19.27 | 6.51 | 12.66 | 13.20 | 51.64 | 5.11 | 10.45 | 15.56 | 100 |
| 1945 | 4.24 | 11.09 | 14.73 | 30.05 | 18.27 | 7.24 | 12.52 | 13.75 | 51.78 | 5.88 | 12.28 | 18.17 | 100 |
| 1945:1941 | .85 | .90 | .95 | .92 | .95 | 1.11 | .99 | 1.04 | 1.00 | 1.15 | 1.18 | 1.17 | ---------- |
| March: | | | | | | | | | | | | | |
| 1941 | 4.95 | 12.76 | 14.83 | 32.55 | 20.06 | 6.33 | 12.50 | 12.91 | 51.79 | 5.59 | 10.07 | 15.66 | 100 |
| 1945 | 4.60 | 10.25 | 14.63 | 29.47 | 19.76 | 7.40 | 12.56 | 13.80 | 53.52 | 5.82 | 11.18 | 17.01 | 100 |
| 1945:1941 | .93 | .80 | .99 | .91 | .99 | 1.17 | 1.00 | 1.07 | 1.03 | 1.04 | 1.11 | 1.09 | ---------- |
| April: | | | | | | | | | | | | | |
| 1941 | 5.53 | 14.25 | 14.50 | 34.28 | 20.95 | 6.10 | 12.36 | 11.53 | 50.95 | 5.06 | 9.72 | 14.77 | 100 |
| 1945 | 4.71 | 12.64 | 14.08 | 31.43 | 18.80 | 7.07 | 12.28 | 13.64 | 51.79 | 5.72 | 11.06 | 16.78 | 100 |
| 1945:1941 | .85 | .89 | .97 | .92 | .90 | 1.16 | .99 | 1.18 | 1.02 | 1.13 | 1.14 | 1.14 | ---------- |
| May: | | | | | | | | | | | | | |
| 1941 | 5.86 | 15.01 | 13.10 | 33.97 | 21.65 | 5.98 | 12.66 | 10.61 | 50.90 | 5.19 | 9.94 | 15.13 | 100 |
| 1945 | 4.68 | 13.03 | 13.66 | 31.36 | 18.84 | 7.03 | 12.50 | 12.85 | 51.22 | 5.92 | 11.49 | 17.42 | 100 |
| 1945:1941 | .80 | .87 | 1.04 | .92 | .87 | 1.18 | .99 | 1.21 | 1.01 | 1.14 | 1.16 | 1.15 | ---------- |
| June: | | | | | | | | | | | | | |
| 1941 | 5.93 | 14.87 | 13.39 | 34.19 | 21.29 | 6.00 | 12.62 | 11.03 | 50.94 | 5.40 | 9.47 | 14.87 | 100 |
| 1945 | 4.42 | 12.10 | 13.41 | 29.93 | 19.09 | 7.12 | 12.76 | 13.15 | 52.12 | 5.91 | 12.04 | 17.95 | 100 |
| 1945:1941 | .75 | .81 | 1.00 | .88 | .90 | 1.19 | 1.01 | 1.19 | 1.02 | 1.09 | 1.27 | 1.21 | ---------- |
| July: | | | | | | | | | | | | | |
| 1941 | 6.42 | 14.87 | 13.47 | 34.76 | 21.80 | 6.01 | 12.31 | 10.12 | 50.25 | 5.47 | 9.52 | 14.99 | 100 |
| 1945 | 4.74 | 13.48 | 13.31 | 31.53 | 19.24 | 6.94 | 11.94 | 12.42 | 50.54 | 5.94 | 11.99 | 17.93 | 100 |
| 1945:1941 | .74 | .91 | .99 | .91 | .88 | 1.15 | .97 | 1.23 | 1.01 | 1.09 | 1.26 | 1.20 | ---------- |
| August: | | | | | | | | | | | | | |
| 1941 | 6.56 | 15.55 | 13.21 | 35.31 | 21.40 | 5.81 | 12.63 | 10.11 | 49.96 | 5.30 | 9.43 | 14.73 | 100 |
| 1945 | 4.77 | 13.75 | 12.44 | 30.96 | 21.26 | 7.28 | 12.01 | 11.76 | 52.31 | 5.81 | 10.92 | 16.73 | 100 |
| 1945:1941 | .73 | .88 | .94 | .88 | .99 | 1.25 | .95 | 1.16 | 1.05 | 1.10 | 1.16 | 1.14 | ---------- |
| September: | | | | | | | | | | | | | |
| 1941 | 6.04 | 14.02 | 13.06 | 34.02 | 21.35 | 6.21 | 12.54 | 11.04 | 51.14 | 5.12 | 9.72 | 14.84 | 100 |
| 1945 | 5.24 | 13.25 | 12.52 | 31.02 | 20.35 | 6.61 | 12.42 | 11.55 | 50.92 | 5.75 | 12.31 | 18.06 | 100 |
| 1945:1941 | .87 | .95 | .96 | .91 | .95 | 1.06 | .99 | 1.05 | 1.00 | 1.12 | 1.27 | 1.22 | ---------- |
| October: | | | | | | | | | | | | | |
| 1941 | 5.99 | 14.20 | 13.33 | 33.53 | 20.75 | 6.35 | 12.99 | 11.56 | 51.64 | 5.24 | 9.59 | 14.83 | 100 |
| 1945 | 4.94 | 13.04 | 13.52 | 31.50 | 18.30 | 6.81 | 12.64 | 12.04 | 49.79 | 6.06 | 12.65 | 18.71 | 100 |
| 1945:1941 | .82 | .92 | 1.01 | .94 | .88 | 1.07 | .97 | 1.04 | .96 | 1.16 | 1.32 | 1.26 | ---------- |
| November: | | | | | | | | | | | | | |
| 1941 | 5.78 | 13.80 | 13.96 | 33.54 | 20.73 | 6.12 | 12.80 | 12.13 | 51.78 | 5.21 | 9.47 | 14.68 | 100 |
| 1945 | 4.48 | 12.39 | 14.16 | 31.02 | 18.47 | 7.06 | 11.60 | 13.30 | 50.43 | 5.63 | 12.91 | 18.55 | 100 |
| 1945:1941 | .78 | .90 | 1.01 | .92 | .89 | 1.15 | .91 | 1.10 | .97 | 1.08 | 1.36 | 1.26 | ---------- |
| December: | | | | | | | | | | | | | |
| 1941 | 5.30 | 12.59 | 14.47 | 32.36 | 20.98 | 6.60 | 12.61 | 13.39 | 53.58 | 4.67 | 9.39 | 14.06 | 100 |
| 1945 | 4.38 | 11.41 | 15.22 | 31.02 | 17.83 | 6.30 | 10.96 | 14.19 | 49.28 | 5.67 | 14.04 | 19.70 | 100 |
| 1945:1941 | .83 | .91 | 1.05 | .96 | .85 | .95 | .87 | 1.06 | .92 | 1.21 | 1.50 | 1.40 | ---------- |
| Total: | | | | | | | | | | | | | |
| 1941 | 5.75 | 14.15 | 13.94 | 33.83 | 20.90 | 6.19 | 12.55 | 11.61 | 51.25 | 5.21 | 9.70 | 14.92 | 100 |
| 1945 | 4.65 | 12.42 | 13.77 | 30.83 | 19.05 | 6.99 | 12.22 | 12.93 | 51.19 | 5.84 | 12.13 | 17.98 | 100 |
| 1945:1941 | .81 | .88 | .99 | .91 | .91 | 1.13 | .97 | 1.11 | 1.00 | 1.12 | 1.25 | 1.20 | ---------- |

TABLE 4.—*Survey period, number of stations operated, number of vehicles counted and weighed in each State in the special weight survey during the summer of 1945*

| Region and State | Survey period | Number of stations | Number of vehicles counted: All military | Number of vehicles counted: All civilian | Number of vehicles counted: Civilian trucks | Number of trucks weighed |
|---|---|---|---|---|---|---|
| New England: | | | | | | |
| Connecticut | July 23–Aug. 7 | 10 | 40 | 17,693 | 3,295 | 1,924 |
| Maine | July 23–Aug. 2 | 8 | 41 | 9,576 | 2,388 | 1,512 |
| Massachusetts [1] | | | | | | |
| New Hampshire | Aug. 13–Aug. 24 | 5 | | 8,842 | 1,091 | 382 |
| Rhode Island [1] | | | | | | |
| Vermont [1] | | | | | | |
| Subtotal | | 23 | 81 | 36,111 | 6,774 | 3,818 |
| Middle Atlantic: | | | | | | |
| New Jersey | Aug. 6–Aug. 13 | 10 | 98 | 38,570 | 8,971 | 1,635 |
| New York | Sept. 25–Sept. 28 | 20 | 63 | 21,875 | 5,749 | 2,759 |
| Pennsylvania | Aug. 6–Aug. 21 | 14 | 134 | 21,981 | 4,496 | 1,135 |
| Subtotal | | 44 | 295 | 82,426 | 19,216 | 5,529 |
| South Atlantic: | | | | | | |
| Delaware | Sept. 10–Sept. 13 | 4 | 97 | 9,449 | 2,578 | 390 |
| Florida [1] | | | | | | |
| Georgia | July 17–July 31 | 10 | 52 | 7,519 | 1,735 | 1,336 |
| Maryland | July 30–Aug. 10 | 10 | 314 | 20,440 | 4,393 | 876 |
| North Carolina | Aug. 6–Aug. 24 | 10 | 85 | 11,056 | 2,519 | 2,240 |
| South Carolina [1] | | | | | | |
| Virginia [1] | | | | | | |
| West Virginia | Aug. 14–Sept. 20 | 9 | | 6,744 | 1,741 | 836 |
| Subtotal | | 43 | 548 | 55,208 | 12,966 | 5,678 |
| East sectional subtotal | | 110 | 924 | 173,745 | 38,956 | 15,025 |
| East North Central: | | | | | | |
| Illinois | Aug. 31–Aug. 29 | 43 | 204 | 49,226 | 9,329 | 4,656 |
| Indiana [1] | | | | | | |
| Michigan | July 26–Aug. 9 | 10 | 59 | 16,554 | 2,884 | 1,245 |
| Ohio [1] | | | | | | |
| Wisconsin | Aug. 2–Aug. 23 | 12 | 90 | 14,522 | 2,589 | 1,910 |
| Subtotal | | 65 | 353 | 80,302 | 14,802 | 7,811 |
| East South Central: | | | | | | |
| Alabama | Aug. 15–Sept. 6 | 10 | 40 | 6,407 | 1,518 | 838 |
| Kentucky | June 20–July 19 | 10 | 141 | 6,023 | 1,516 | 608 |
| Mississippi | Aug. 13–Sept. 6 | 15 | 149 | 13,399 | 3,172 | 2,995 |
| Tennessee | July 23–Aug. 3 | 10 | 9 | 4,925 | 1,509 | 553 |
| Subtotal | | 45 | 339 | 30,754 | 7,715 | 4,994 |
| West North Central: | | | | | | |
| Iowa | July 24–Aug. 6 | 10 | 32 | 5,902 | 1,269 | 1,218 |
| Kansas | Aug. 16–Aug. 30 | 10 | 37 | 6,109 | 1,312 | 1,210 |
| Minnesota | Aug. 6–Aug. 24 | 10 | 10 | 8,050 | 1,603 | 1,259 |
| Missouri [1] | | | | | | |
| Nebraska | July 26–Aug. 9 | 11 | 58 | 5,741 | 1,523 | 1,461 |
| North Dakota | Aug. 2–Aug. 30 | 10 | | 8,266 | 2,092 | 1,435 |
| South Dakota | July 30–Aug. 29 | 12 | 24 | 4,034 | 889 | 861 |
| Subtotal | | 63 | 161 | 38,102 | 8,688 | 7,444 |
| West South Central: | | | | | | |
| Arkansas | July 23–Aug. 3 | 10 | 112 | 8,185 | 2,593 | 1,203 |
| Louisiana | July 23–Aug. 3 | 10 | 137 | 5,726 | 1,555 | 945 |
| Oklahoma | Aug. 20–Aug. 21 | 10 | 110 | 9,826 | 2,019 | 2,019 |
| Texas | July 30–Aug. 24 | 18 | 252 | 18,453 | 4,117 | 3,122 |
| Subtotal | | 48 | 611 | 42,190 | 10,284 | 7,289 |
| Midwest sectional subtotal | | 221 | 1,464 | 191,348 | 41,489 | 27,538 |
| Mountain: | | | | | | |
| Arizona | July 16–July 27 | 10 | 74 | 4,471 | 984 | 452 |
| Colorado | July 20–Aug. 3 | 10 | 199 | 10,631 | 2,132 | 638 |
| Idaho | Aug. 6–Aug. 29 | 13 | 49 | 7,577 | 1,521 | 1,283 |
| Montana | Aug. 1–Aug. 28 | 20 | 40 | 8,224 | 2,008 | 1,911 |
| Nevada | July 31–Aug. 14 | 10 | 95 | 3,723 | 665 | 633 |
| New Mexico | July 23–Aug. 8 | 10 | 196 | 5,805 | 1,481 | 1,092 |
| Utah [1] | | | | | | |
| Wyoming | Aug. 1–Aug. 14 | 10 | 47 | 3,790 | 796 | 717 |
| Subtotal | | 83 | 700 | 44,221 | 9,587 | 6,726 |
| Pacific: | | | | | | |
| California | Aug. 21–Sept. 21 | 17 | 533 | 58,943 | 10,634 | 2,669 |
| Oregon [1] | | | | | | |
| Washington | Sept. 5–Sept. 18 | 10 | 358 | 14,445 | 1,932 | 1,353 |
| Subtotal | | 27 | 891 | 73,388 | 12,566 | 4,022 |
| West sectional subtotal | | 110 | 1,591 | 117,609 | 22,153 | 10,748 |
| United States total | | 441 | 3,979 | 482,702 | 102,598 | 53,311 |

[1] Survey not made.

TABLE 5.—*Ratio of 1945 summer counts to corresponding counts in 1944, by regions*

| Region | Military vehicles | Civilian vehicles: All | Passenger cars: All | Passenger cars: Local | Passenger cars: Foreign | Trucks and truck combinations: All | Trucks and truck combinations: Single units | Trucks and truck combinations: Combinations | Busses |
|---|---|---|---|---|---|---|---|---|---|
| Eastern regions: | | | | | | | | | |
| New England | 0.49 | 1.20 | 1.21 | 1.15 | 1.40 | 1.17 | 1.17 | 1.17 | 1.11 |
| Middle Atlantic | .41 | 1.20 | 1.24 | 1.18 | 1.84 | 1.08 | 1.05 | 1.15 | 1.16 |
| South Atlantic | .55 | 1.18 | 1.24 | 1.23 | 1.25 | 1.03 | 1.06 | .97 | 1.22 |
| Average | .50 | 1.19 | 1.23 | 1.20 | 1.40 | 1.06 | 1.07 | 1.04 | 1.18 |
| Midwest regions: | | | | | | | | | |
| East North Central | .68 | 1.15 | 1.18 | 1.21 | 1.49 | 1.07 | 1.06 | 1.10 | .98 |
| East South Central | .65 | 1.15 | 1.20 | 1.21 | 1.17 | 1.01 | 1.03 | .96 | .93 |
| West North Central | .63 | 1.18 | 1.20 | 1.14 | 1.67 | 1.11 | 1.11 | 1.10 | 1.24 |
| West South Central | .82 | 1.14 | 1.17 | 1.09 | 1.68 | 1.06 | 1.07 | 1.05 | 1.05 |
| Average | .72 | 1.16 | 1.18 | 1.13 | 1.50 | 1.07 | 1.07 | 1.07 | 1.03 |
| Western regions: | | | | | | | | | |
| Mountain | 1.39 | 1.24 | 1.31 | 1.22 | 1.58 | 1.04 | 1.02 | 1.13 | 1.09 |
| Pacific | .37 | 1.38 | 1.41 | 1.36 | 1.82 | 1.33 | 1.31 | 1.37 | .89 |
| Average | .52 | 1.33 | 1.37 | 1.32 | 1.68 | 1.23 | 1.19 | 1.33 | .96 |
| United States average | .59 | 1.20 | 1.23 | 1.18 | 1.49 | 1.10 | 1.09 | 1.11 | 1.07 |

busses were counted but were not stopped. All trucks stopped were weighed and the heavier vehicles were also measured. Information was recorded concerning the type of vehicle whether loaded or empty, number of axles, the manufacturers' rated capacity, and the load on each wheel on one side of the vehicle. The distance between axles of single-unit trucks weighing 13 tons or more and of combinations weighing 17 tons or more also was recorded. The number of vehicles weighed was 53,311 or 52.0 percent of the civilian trucks passing the stations.

### TRENDS DETERMINED BY THE SUMMER WEIGHT SURVEY

The ratio of the numbers of the various types of vehicles counted in the 1945 summer survey as compared to the corresponding counts of 1944 are given in table 5 for each region of the country and for the United States. During 1945 there was a large general reduction in military traffic and a recovery of civilian traffic. The increase in military traffic found in the Mountain States was concentrated largely in Colorado and New Mexico.

In table 6 is shown a comparison by census regions of the estimated vehicle-miles traveled on all main rural roads in 1941, 1944, and 1945 by all types of vehicles and by trucks and truck combinations. This table shows the average carried loads and ton-mileage in each of the 3 years, and percentage relation between those years.

The vehicle-mileage of trucks increased in all regions from 1944 to 1945 and ton-mileage increased in all except the East South Central region. For the country as a whole the vehicle-mileage increase amounted to 10 percent and the ton-mileage increase amounted to 13 percent, there being a slight increase in the average weight of the carried load. In the Pacific region the increase was 33 percent for vehicle-miles and 41 percent for ton-miles, reflecting the greater activity in that region during 1945 as war activities increased in the Pacific. There was no significant change in the relation between single-unit trucks and truck combinations except in the two western regions where there was an

TABLE 6.—*Comparison of estimated 1945 vehicle-miles, percentage loaded, average carried load and ton-miles on main rural roads with corresponding figures for 1941 and 1944*

| Region and year | All vehicles vehicle-miles | All trucks (including combinations): Percentage of all vehicles | All trucks: Vehicle-miles | All trucks: Percentage loaded | All trucks: Carried load: Average weight | All trucks: Carried load: Ton-miles | Single-unit trucks: Percentage of all trucks and combinations | Single-unit trucks: Vehicle-miles | Single-unit trucks: Percentage loaded | Single-unit trucks: Carried load: Average weight | Single-unit trucks: Carried load: Ton-miles | Truck combinations: Percentage of all trucks and combinations | Truck combinations: Vehicle-miles | Truck combinations: Percentage loaded | Truck combinations: Carried load: Average weight | Truck combinations: Carried load: Ton-miles |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EASTERN REGION: New England: | *Thousands* | | *Thousands* | | *Tons* | *Thousands* | | *Thousands* | | *Tons* | *Thousands* | | *Thousands* | | *Tons* | *Thousands* |
| 1941 | 6, 663, 830 | 14. 7 | 980, 695 | 72. 9 | 2. 79 | 1, 993, 120 | 90. 5 | 887, 783 | 72. 7 | 2. 22 | 1, 435, 923 | 9. 5 | 92, 912 | 74. 3 | 8. 06 | 557, 197 |
| 1944 | 3, 297, 741 | 19. 9 | 656, 888 | 54. 8 | 3. 97 | 1, 429, 887 | 81. 0 | 531, 951 | 51. 4 | 2. 42 | 660, 579 | 19. 0 | 124, 937 | 69. 3 | 8. 88 | 769, 308 |
| 1945 | 3, 928, 601 | 19. 6 | 769, 497 | 53. 8 | 3. 92 | 1, 623, 664 | 81. 0 | 623, 565 | 50. 9 | 2. 27 | 721, 397 | 19. 0 | 145, 932 | 66. 4 | 9. 31 | 902, 267 |
| 1945:1941 | . 59 | 1. 33 | . 78 | . 74 | 1. 41 | . 81 | . 90 | . 70 | . 70 | 1. 02 | . 50 | 2. 00 | 1. 57 | . 89 | 1. 16 | 1. 62 |
| 1945:1944 | 1. 19 | . 98 | 1. 17 | . 98 | . 99 | 1. 14 | . 90 | 1. 17 | . 99 | . 94 | 1. 09 | 1. 00 | 1. 17 | . 96 | 1. 05 | 1. 17 |
| Middle Atlantic: | | | | | | | | | | | | | | | | |
| 1941 | 17, 108, 107 | 20. 2 | 3, 447, 631 | 70. 3 | 3. 41 | 8, 267, 429 | 81. 0 | 2, 793, 416 | 69. 9 | 2. 14 | 4, 175, 576 | 19. 0 | 654, 215 | 72. 1 | 8. 67 | 4, 091, 853 |
| 1944 | 9, 010, 063 | 24. 1 | 2, 171, 217 | 55. 8 | 4. 14 | 5, 014, 668 | 75. 8 | 1, 646, 177 | 53. 5 | 2. 35 | 2, 073, 208 | 24. 2 | 525, 040 | 63. 1 | 8. 87 | 2, 941, 460 |
| 1945 | 10, 725, 475 | 21. 8 | 2, 337, 486 | 54. 6 | 4. 30 | 5, 487, 126 | 74. 2 | 1, 735, 098 | 51. 9 | 2. 36 | 2, 129, 030 | 25. 8 | 602, 388 | 62. 3 | 8. 95 | 3, 358, 096 |
| 1945:1941 | . 63 | 1. 08 | . 68 | . 78 | 1. 26 | . 66 | . 92 | . 62 | . 74 | 1. 10 | . 51 | 1. 36 | . 92 | . 86 | 1. 03 | . 82 |
| 1945:1944 | 1. 19 | . 90 | 1. 08 | . 98 | 1. 04 | 1. 09 | . 98 | 1. 05 | . 97 | 1. 00 | 1. 03 | 1. 07 | 1. 15 | . 99 | 1. 01 | 1. 14 |
| South Atlantic: | | | | | | | | | | | | | | | | |
| 1941 | 18, 612, 782 | 23. 2 | 4, 315, 146 | 65. 6 | 3. 88 | 10, 982, 765 | 77. 8 | 3, 357, 800 | 64. 6 | 2. 61 | 5, 663, 491 | 22. 2 | 957, 346 | 69. 0 | 8. 05 | 5, 319, 274 |
| 1944 | 10, 978, 795 | 26. 6 | 2, 917, 279 | 58. 9 | 4. 85 | 8, 345, 945 | 68. 7 | 2, 002, 776 | 55. 2 | 2. 52 | 2, 782, 538 | 31. 3 | 914, 503 | 67. 2 | 9. 06 | 5, 563, 407 |
| 1945 | 12, 835, 292 | 23. 4 | 3, 007, 162 | 57. 4 | 4. 84 | 8, 350, 393 | 70. 6 | 2, 121, 565 | 53. 2 | 2. 48 | 2, 803, 119 | 29. 4 | 885, 597 | 67. 5 | 9. 28 | 5, 547, 274 |
| 1945:1941 | . 69 | 1. 01 | . 70 | . 88 | 1. 25 | . 76 | . 91 | . 63 | . 82 | . 95 | . 49 | 1. 32 | . 93 | . 98 | 1. 15 | 1. 04 |
| 1945:1944 | 1. 17 | . 88 | 1. 03 | . 97 | 1. 00 | 1. 00 | 1. 03 | 1. 06 | . 96 | . 98 | 1. 01 | . 94 | . 97 | 1. 00 | 1. 02 | 1. 00 |
| Subtotal: | | | | | | | | | | | | | | | | |
| 1941 | 42, 384, 719 | 20. 6 | 8, 743, 472 | 68. 2 | 3. 56 | 21, 243, 314 | 80. 5 | 7, 038, 999 | 67. 7 | 2. 37 | 11, 274, 990 | 19. 5 | 1, 704, 473 | 70. 5 | 8. 30 | 9, 968, 324 |
| 1944 | 23, 286, 599 | 24. 7 | 5, 745, 384 | 57. 3 | 4. 49 | 14, 790, 500 | 72. 8 | 4, 180, 904 | 54. 0 | 2. 44 | 5, 516, 325 | 27. 2 | 1, 564, 480 | 66. 0 | 8. 98 | 9, 274, 175 |
| 1945 | 27, 489, 368 | 22. 2 | 6, 114, 145 | 55. 9 | 4. 53 | 15, 461, 183 | 73. 3 | 4, 480, 228 | 52. 4 | 2. 41 | 5, 653, 546 | 26. 7 | 1, 633, 917 | 65. 4 | 9. 17 | 9, 807, 637 |
| 1945:1941 | . 65 | 1. 08 | . 70 | . 82 | 1. 27 | . 73 | . 91 | . 64 | . 77 | 1. 02 | . 50 | 1. 37 | . 96 | . 93 | 1. 10 | . 98 |
| 1945:1944 | 1. 18 | . 90 | 1. 06 | . 98 | 1. 01 | 1. 05 | 1. 01 | 1. 07 | . 97 | . 99 | 1. 02 | . 98 | 1. 04 | . 99 | 1. 02 | 1. 06 |
| MIDWEST REGION: East North Central: | | | | | | | | | | | | | | | | |
| 1941 | 24, 192, 260 | 17. 8 | 4, 305, 309 | 68. 7 | 4. 05 | 11, 961, 648 | 68. 0 | 2, 926, 163 | 66. 0 | 2. 10 | 4, 064, 158 | 32. 0 | 1, 379, 146 | 74. 3 | 7. 71 | 7, 897, 490 |
| 1944 | 13, 944, 387 | 19. 7 | 2, 743, 759 | 61. 2 | 4. 86 | 8, 171, 775 | 63. 7 | 1, 746, 699 | 52. 8 | 2. 13 | 1, 967, 162 | 36. 3 | 997, 060 | 76. 1 | 8. 18 | 6, 204, 613 |
| 1945 | 16, 018, 709 | 18. 4 | 2, 940, 681 | 58. 7 | 5. 15 | 8, 897, 279 | 62. 9 | 1, 848, 320 | 49. 4 | 2. 38 | 2, 176, 246 | 37. 1 | 1, 092, 361 | 74. 4 | 8. 27 | 6, 721, 033 |
| 1945:1941 | . 66 | 1. 03 | . 68 | . 85 | 1. 27 | . 74 | . 92 | . 63 | . 75 | 1. 13 | . 54 | 1. 16 | . 79 | 1. 00 | 1. 07 | . 85 |
| 1945:1944 | 1. 15 | . 93 | 1. 07 | . 96 | 1. 06 | 1. 09 | . 99 | 1. 06 | . 94 | 1. 12 | 1. 11 | 1. 02 | 1. 10 | . 98 | 1. 01 | 1. 08 |
| East South Central: | | | | | | | | | | | | | | | | |
| 1941 | 7, 533, 991 | 21. 7 | 1, 632, 240 | 64. 8 | 3. 13 | 3, 303, 537 | 90. 0 | 1, 469, 033 | 64. 1 | 2. 70 | 2, 546, 285 | 10. 0 | 163, 207 | 70. 5 | 6. 58 | 757, 252 |
| 1944 | 5, 030, 873 | 22. 2 | 1, 118, 954 | 50. 4 | 4. 19 | 2, 364, 060 | 81. 7 | 913, 756 | 46. 3 | 2. 90 | 1, 225, 738 | 18. 3 | 205, 198 | 68. 7 | 8. 08 | 1, 138, 322 |
| 1945 | 5, 423, 111 | 20. 9 | 1, 134, 490 | 47. 0 | 4. 01 | 2, 136, 854 | 82. 7 | 938, 635 | 43. 4 | 2. 72 | 1, 108, 602 | 17. 3 | 195, 855 | 63. 8 | 8. 23 | 1, 028, 252 |
| 1945:1941 | . 72 | . 96 | . 70 | . 73 | 1. 28 | . 65 | . 92 | . 64 | . 68 | 1. 01 | . 44 | 1. 73 | 1. 20 | . 90 | 1. 25 | 1. 36 |
| 1945:1944 | 1. 08 | . 94 | 1. 01 | . 93 | . 96 | . 90 | 1. 01 | 1. 03 | . 94 | . 94 | . 90 | . 95 | . 95 | . 93 | 1. 02 | . 90 |
| West North Central: | | | | | | | | | | | | | | | | |
| 1941 | 15, 260, 119 | 20. 8 | 3, 172, 121 | 67. 0 | 3. 23 | 6, 872, 720 | 80. 8 | 2, 563, 019 | 66. 3 | 2. 09 | 3, 549, 465 | 19. 2 | 609, 102 | 70. 1 | 7. 79 | 3, 323, 255 |
| 1944 | 8, 677, 255 | 24. 6 | 2, 135, 475 | 61. 0 | 3. 41 | 4, 433, 066 | 78. 0 | 1, 666, 466 | 59. 9 | 1. 94 | 1, 963, 870 | 22. 0 | 469, 009 | 64. 7 | 8. 14 | 2, 469, 196 |
| 1945 | 10, 180, 874 | 23. 3 | 2, 367, 392 | 58. 8 | 3. 67 | 5, 111, 866 | 78. 3 | 1, 853, 832 | 55. 8 | 1. 98 | 2, 053, 160 | 21. 7 | 513, 560 | 69. 5 | 8. 57 | 3, 058, 706 |
| 1945:1941 | . 67 | 1. 12 | . 75 | . 88 | 1. 14 | . 74 | . 97 | . 72 | . 84 | . 95 | . 58 | 1. 13 | . 84 | . 99 | 1. 10 | . 92 |
| 1945:1944 | 1. 17 | . 95 | 1. 11 | . 96 | 1. 08 | 1. 15 | 1. 00 | 1. 11 | . 93 | 1. 02 | 1. 05 | . 99 | 1. 09 | 1. 07 | 1. 05 | 1. 24 |
| West South Central: | | | | | | | | | | | | | | | | |
| 1941 | 13, 745, 126 | 21. 8 | 2, 994, 305 | 60. 6 | 2. 99 | 5, 427, 182 | 78. 9 | 2, 362, 360 | 59. 6 | 2. 23 | 3, 144, 368 | 21. 1 | 631, 945 | 64. 5 | 5. 60 | 2, 282, 814 |
| 1944 | 9, 445, 823 | 25. 7 | 2, 426, 267 | 44. 6 | 3. 78 | 4, 085, 999 | 73. 7 | 1, 789, 322 | 39. 6 | 2. 47 | 1, 746, 957 | 26. 3 | 636, 945 | 58. 5 | 6. 28 | 2, 339, 042 |
| 1945 | 10, 724, 349 | 24. 1 | 2, 583, 820 | 42. 6 | 3. 79 | 4, 165, 546 | 74. 1 | 1, 914, 077 | 37. 1 | 2. 54 | 1, 808, 167 | 25. 9 | 669. 743 | 58. 2 | 6. 05 | 2, 357, 379 |
| 1945:1941 | . 78 | 1. 11 | . 86 | . 70 | 1. 27 | . 77 | . 94 | . 81 | . 62 | 1. 14 | . 58 | 1. 23 | 1. 06 | . 90 | 1. 08 | 1. 03 |
| 1945:1944 | 1. 14 | . 94 | 1. 06 | . 96 | 1. 00 | 1. 02 | 1. 01 | 1. 07 | . 94 | 1. 03 | 1. 04 | . 98 | 1. 05 | . 99 | . 96 | 1. 01 |
| Subtotal: | | | | | | | | | | | | | | | | |
| 1941 | 60, 731, 496 | 19. 9 | 12, 103, 975 | 65. 7 | 3. 47 | 27, 565, 087 | 77. 0 | 9, 320, 575 | 64. 2 | 2. 22 | 13, 304, 276 | 23. 0 | 2, 783, 400 | 70. 9 | 7. 23 | 14, 260, 811 |
| 1944 | 37, 098, 338 | 22. 7 | 8, 424, 455 | 54. 9 | 4. 12 | 19, 054, 900 | 72. 6 | 6, 116, 243 | 49. 9 | 2. 21 | 6, 903, 727 | 27. 4 | 2, 308, 212 | 68. 2 | 7. 71 | 12, 151, 173 |
| 1945 | 42, 347, 043 | 21. 3 | 9, 026, 383 | 52. 6 | 4. 48 | 20, 311, 545 | 72. 6 | 6, 554, 864 | 46. 8 | 2. 33 | 7, 146, 175 | 27. 4 | 2, 471, 519 | 68. 1 | 7. 82 | 13, 165, 370 |
| 1945:1941 | . 70 | 1. 07 | . 75 | . 80 | 1. 29 | . 74 | . 94 | . 70 | . 73 | 1. 05 | . 54 | 1. 19 | . 89 | . 96 | 1. 08 | . 92 |
| 1945:1944 | 1. 14 | . 94 | 1. 07 | . 96 | 1. 09 | 1. 07 | 1. 00 | 1. 07 | . 94 | 1. 05 | 1. 04 | 1. 00 | 1. 07 | 1. 00 | 1. 01 | 1. 08 |
| WESTERN REGION: Mountain: | | | | | | | | | | | | | | | | |
| 1941 | 6, 741, 489 | 19. 5 | 1, 316, 246 | 62. 6 | 3. 39 | 2, 795, 644 | 88. 0 | 1, 158, 270 | 61. 6 | 2. 46 | 1, 755, 379 | 12. 0 | 157, 976 | 69. 7 | 9. 45 | 1, 040, 265 |
| 1944 | 4, 181, 810 | 25. 8 | 1, 078, 077 | 44. 2 | 4. 52 | 2, 170, 648 | 84. 7 | 912, 870 | 39. 4 | 2. 60 | 909, 968 | 15. 3 | 165, 207 | 70. 8 | 10. 66 | 1, 260, 680 |
| 1945 | 5, 194, 915 | 21. 5 | 1, 118, 716 | 45. 8 | 4. 63 | 2, 374, 966 | 83. 3 | 931, 905 | 41. 5 | 2. 51 | 950, 677 | 16. 7 | 186, 811 | 71. 5 | 10. 66 | 1, 424, 289 |
| 1945:1941 | . 77 | 1. 10 | . 85 | . 73 | 1. 37 | . 85 | . 95 | . 80 | . 67 | 1. 02 | . 54 | 1. 39 | 1. 18 | 1. 03 | 1. 13 | 1. 37 |
| 1945:1944 | 1. 24 | . 83 | 1. 04 | 1. 04 | 1. 02 | 1. 09 | . 98 | 1. 02 | 1. 05 | . 97 | 1. 00 | 1. 09 | 1. 13 | 1. 01 | 1. 00 | 1. 13 |
| Pacific: | | | | | | | | | | | | | | | | |
| 1941 | 12, 647, 141 | 16. 0 | 2, 021, 200 | 68. 8 | 5. 13 | 7, 132, 737 | 76. 1 | 1, 538, 563 | 65. 2 | 2. 14 | 2, 151, 962 | 23. 9 | 482, 637 | 80. 4 | 12. 84 | 4, 980, 775 |
| 1944 | 8, 073, 814 | 24. 6 | 1, 986, 703 | 63. 7 | 6. 85 | 8, 680, 071 | 62. 9 | 1, 249, 258 | 54. 1 | 2. 45 | 1, 657, 480 | 37. 1 | 737, 445 | 80. 1 | 11. 89 | 7, 022, 591 |
| 1945 | 10, 761, 149 | 15. 3 | 2, 647, 932 | 65. 4 | 7. 05 | 12, 216, 924 | 61. 7 | 1, 634, 744 | 58. 1 | 2. 57 | 2, 435, 956 | 38. 3 | 1, 013, 188 | 77. 3 | 12. 49 | 9, 780, 968 |
| 1945:1941 | . 85 | . 96 | 1. 31 | . 95 | 1. 37 | 1. 71 | . 81 | 1. 06 | . 89 | 1. 20 | 1. 13 | 1. 60 | 2. 10 | . 96 | . 97 | 1. 96 |
| 1945:1944 | 1. 33 | . 62 | 1. 33 | 1. 03 | 1. 03 | 1. 41 | . 98 | 1. 27 | 1. 07 | 1. 05 | 1. 47 | 1. 03 | 1. 37 | . 96 | 1. 05 | 1. 39 |
| Subtotal: | | | | | | | | | | | | | | | | |
| 1941 | 19, 388, 630 | 17. 2 | 3, 337, 446 | 66. 4 | 4. 48 | 9, 928, 381 | 80. 8 | 2, 696, 833 | 63. 7 | 2. 27 | 3, 907, 341 | 19. 2 | 640, 613 | 77. 7 | 12. 09 | 6, 021, 040 |
| 1944 | 12, 255, 624 | 25. 0 | 3, 064, 780 | 56. 9 | 6. 22 | 10, 850, 719 | 70. 5 | 2, 162, 128 | 47. 9 | 2. 48 | 2, 567, 448 | 29. 5 | 902, 652 | 78. 4 | 11. 70 | 8, 283, 271 |
| 1945 | 15, 956, 064 | 23. 6 | 3, 766, 648 | 59. 6 | 6. 50 | 14, 591, 890 | 68. 1 | 2, 566, 649 | 51. 8 | 2. 55 | 3, 386, 633 | 31. 9 | 1, 199, 999 | 76. 4 | 12. 22 | 11, 205, 257 |
| 1945:1941 | . 82 | 1. 37 | 1. 13 | . 90 | 1. 45 | 1. 47 | . 84 | . 95 | . 81 | 1. 12 | . 87 | 1. 66 | 1. 87 | . 98 | 1. 01 | 1. 86 |
| 1945:1944 | 1. 30 | . 94 | 1. 23 | 1. 05 | 1. 05 | 1. 34 | . 97 | 1. 19 | 1. 08 | 1. 03 | 1. 32 | 1. 08 | 1. 33 | . 97 | 1. 04 | 1. 35 |
| UNITED STATES TOTAL: | | | | | | | | | | | | | | | | |
| 1941 | 122, 504, 845 | 19. 7 | 24, 184, 893 | 66. 7 | 3. 64 | 58, 736, 782 | 78. 8 | 19, 056, 407 | 65. 4 | 2. 29 | 28, 486, 607 | 21. 2 | 5, 128, 486 | 71. 6 | 8. 23 | 30, 250, 175 |
| 1944 | 72, 640, 561 | 23. 7 | 17, 234, 619 | 56. 1 | 4. 63 | 44, 696, 119 | 72. 3 | 12, 459, 275 | 50. 9 | 2. 36 | 14, 987, 500 | 27. 7 | 4, 775, 344 | 69. 4 | 8. 96 | 29, 708, 619 |
| 1945 | 85, 792, 475 | 22. 0 | 18, 907, 176 | 55. 1 | 4. 84 | 50, 364, 618 | 71. 9 | 13, 601, 741 | 49. 6 | 2. 40 | 16, 186, 354 | 28. 1 | 5, 305, 435 | 69. 2 | 9. 31 | 34, 178, 264 |
| 1945:1941 | . 70 | 1. 12 | . 78 | . 83 | 1. 33 | . 86 | . 91 | . 71 | . 76 | 1. 05 | . 57 | 1. 33 | 1. 03 | . 97 | 1. 13 | 1. 13 |
| 1945:1944 | 1. 18 | . 93 | 1. 10 | . 98 | 1. 05 | 1. 13 | . 99 | 1. 09 | . 97 | 1. 02 | 1. 08 | 1. 01 | 1. 11 | 1. 00 | 1. 04 | 1. 15 |

TABLE 7.—*Average maximum axle load of loaded trucks in the summer of 1945 and in corresponding periods of 1944 and 1942 and in the prewar years between 1936 and 1941*

[In pounds]

| Region | All trucks and combinations | | | | Single-unit trucks | | | | Truck combinations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar |
| New England | 10,005 | 10,221 | 9,310 | 7,647 | 7,990 | 8,372 | 7,977 | 6,985 | 16,621 | 15,758 | 14,605 | 13,951 |
| Middle Atlantic | 11,584 | 11,318 | 10,865 | 7,858 | 9,346 | 9,118 | 8,938 | 6,779 | 16,768 | 16,769 | 16,027 | 13,551 |
| South Atlantic | 9,950 | 10,246 | 9,146 | 8,488 | 7,632 | 8,070 | 7,206 | 7,589 | 15,403 | 15,709 | 14,416 | 11,8 1 |
| East North Central | 11,678 | 11,103 | 10,259 | 8,290 | 8,595 | 8,085 | 7,829 | 6,806 | 14,797 | 14,659 | 13,789 | 12,090 |
| East South Central | 9,024 | 9,372 | 8,325 | 7,215 | 8,003 | 8,152 | 7,414 | 6,962 | 14,157 | 13,001 | 11,732 | 8,899 |
| West North Central | 9,300 | 9,218 | 8,798 | 7,593 | 7,212 | 7,167 | 7,019 | 6,565 | 14,633 | 14,118 | 13,560 | 11,594 |
| West South Central | 7,673 | 7,717 | 7,441 | 5,868 | 5,834 | 5,798 | 5,422 | 5,134 | 14,297 | 11,981 | 12,050 | 8,391 |
| Mountain | 8,858 | 8,551 | 8,225 | 6,051 | 7,110 | 7,118 | 6,785 | 5,444 | 14,118 | 13,763 | 13,896 | 11,284 |
| Pacific | 9,995 | 10,207 | 8,980 | 7,094 | 8,497 | 8,668 | 7,344 | 5,967 | 13,504 | 13,746 | 13,355 | 11,176 |
| United States average | 10,017 | 9,967 | 9,160 | 7,552 | 7,869 | 7,857 | 7,294 | 6,566 | 14,615 | 14,848 | 13,788 | 11,449 |

appreciable increase in the usage of the heavier type of vehicle.

The comparison between the data for 1945, the last year of the war, and those for 1941, the last prewar year, shows that truck vehicle-mileage dropped 22 percent and that the percentage of loaded vehicles decreased from 66.7 to 55.1, but that notwithstanding this the ton-mileage hauled dropped only 14 percent. The reason for the comparatively small drop in ton-mileage was a 33 percent increase in the average weight of carried load, due largely to the increased proportion of heavy truck combinations in the total number of trucks. In 1941, 21.2 percent of the cargo vehicles on the road were combinations, and in 1945 this percentage had increased to 28.1. There was also some increase in the average weight of the load carried by both truck combinations and single-unit trucks.

#### FREQUENCY OF HEAVY LOADS INCREASED

Table 7 shows the average maximum axle load of loaded vehicles in the summer of 1945 and in corresponding periods of previous years when such data were collected. Axle loads in 1945 were substantially the same as in 1944 but were much heavier on the average than in prewar years. For the United States as a whole the average maximum axle load increased from 7,552 pounds in the prewar period to 10,017 in 1945.

While the average maximum axle loads increased during the war, frequency of the heavier axle loads also increased. The increase in the frequency of these heavier loads is shown in table 8. It will be noted that in each weight group for which data are included in the table there was an increase in the frequency of the heavier loads, and that in each of the three cases the frequency in 1945 was about five times the frequency found in the original prewar survey. The highest frequency of heavy axle loads is found in the Middle Atlantic region with the second highest frequency in the New England area. Other regions are far behind these two.

The frequency of heavy vehicles is shown in table 9. It will be observed that the heavier units have become more frequent throughout the war and in 1945 were far more frequent than in the prewar period. For example, of each 1,000 trucks weighed in the survey made before the war only three were as heavy as 50,000 pounds, while in 1945 the proportion of trucks this heavy amounted to twenty-three per 1,000. These extremely heavy vehicles are found principally in the Pacific region, but are on the increase throughout the country.

In limiting loads to prevent overstressing bridges both the spacing of axles and the actual axle loads should be taken into account in determining the permissible gross load. The so-called gross load formula has been widely used to indicate permissible combinations of axle loads and spacings. The formula referred to is $W=C\ (L+40)$ in which $W$ is the total weight of the vehicle in pounds, or the weight of an interior group of axles, and $L$ is the distance in feet between the first

TABLE 8.—*Number of axle loads of 18,000, 20,000, and 22,000 pounds or more per 1,000 loaded and empty trucks and combinations in the summers of 1945, 1944, 1942, and in the prewar period between 1936 and 1941*

| Region | Number of heavy axle loads per 1,000 loaded and empty trucks and combinations of— | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 18,000 pounds or more | | | | 20,000 pounds or more | | | | 22,000 pounds or more | | | |
| | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar |
| New England | 109 | 108 | 65 | 48 | 62 | 55 | 26 | 21 | 29 | 25 | 12 | 8 |
| Middle Atlantic | 149 | 138 | 91 | 40 | 75 | 72 | 45 | 18 | 33 | 48 | 18 | 7 |
| South Atlantic | 78 | 64 | 45 | 7 | 26 | 23 | 14 | 1 | 7 | 9 | 4 | [1] 0 |
| East North Central | 74 | 70 | 48 | 14 | 10 | 17 | 11 | 4 | 5 | 5 | 3 | 2 |
| East South Central | 30 | 29 | 14 | 1 | 15 | 11 | 7 | [1] 0 | 6 | 3 | 4 | [1] 0 |
| West North Central | 41 | 37 | 29 | 5 | 8 | 7 | 6 | [1] 0 | 1 | 1 | 1 | [1] 0 |
| West South Central | 25 | 28 | 18 | 4 | 8 | 9 | 4 | 2 | 2 | 5 | 2 | [1] 0 |
| Mountain | 44 | 20 | 24 | 5 | 12 | 6 | 5 | 3 | 3 | 2 | 1 | 2 |
| Pacific | 47 | 62 | 24 | 3 | 13 | 17 | 4 | 1 | 3 | 3 | 2 | [1] 0 |
| United States average | 67 | 64 | 41 | 13 | 23 | 23 | 13 | 5 | 9 | 11 | 5 | 2 |

[1] Less than 5 per 10,000 counted.

TABLE 9.—*Number of gross weights of 30,000, 40,000, and 50,000 pounds or more per 1,000 loaded and empty trucks and combinations in the summers of 1945, 1944, 1942, and in the prewar period between 1936 and 1941*

| Region | Number of gross weights per 1,000 vehicles— | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30,000 pounds or more | | | | 40,000 pounds or more | | | | 50,000 pounds or more | | | |
| | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar | 1945 | 1944 | 1942 | Prewar |
| New England | 113 | 120 | 97 | 58 | 50 | 51 | 30 | 15 | 10 | 6 | 3 | 1 |
| Middle Atlantic | 163 | 172 | 142 | 62 | 77 | 70 | 48 | 17 | 18 | 16 | 12 | 3 |
| South Atlantic | 133 | 120 | 97 | 32 | 43 | 32 | 21 | 3 | 2 | 3 | 1 | [1] 0 |
| East North Central | 233 | 221 | 175 | 65 | 72 | 58 | 40 | 13 | 28 | 21 | 10 | 5 |
| East South Central | 57 | 63 | 39 | 7 | 12 | 10 | 2 | 1 | 1 | [1] 0 | 1 | [1] 0 |
| West North Central | 114 | 110 | 91 | 34 | 33 | 27 | 16 | 2 | 11 | 7 | 1 | [1] 0 |
| West South Central | 73 | 62 | 59 | 8 | 20 | 14 | 8 | 1 | 3 | 2 | 1 | [1] 0 |
| Mountain | 98 | 80 | 76 | 20 | 54 | 42 | 41 | 7 | 28 | 22 | 21 | 3 |
| Pacific | 156 | 170 | 155 | 97 | 116 | 109 | 110 | 47 | 86 | 83 | 81 | 24 |
| United States average | 144 | 134 | 111 | 43 | 58 | 47 | 33 | 11 | 23 | 19 | 12 | 3 |

[1] Less than 5 per 10,000 counted.

Table 10.—*Number of trucks with values of C* [1] *in the gross weight formula in excess of various values, per 1,000 loaded and empty trucks and combinations in the summers of 1945, 1944, and 1942*

| Region | Number of trucks and combinations with values of *C*— | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Over 650 | | | Over 700 | | | Over 750 | | | Over 800 | | | Over 850 | | | Over 900 | | |
| | 1945 | 1944 | 1942 | 1945 | 1944 | 1942 | 1945 | 1944 | 1942 | 1945 | 1944 | 1942 | 1945 | 1944 | 1942 | 1945 | 1944 | 1942 |
| New England | 33 | 35 | 21 | 18 | 18 | 11 | 9 | 8 | 5 | 4 | 4 | 2 | 2 | 1 | 1 | 1 | 1 | 0 |
| Middle Atlantic | 56 | 48 | 35 | 33 | 31 | 23 | 18 | 20 | 13 | 9 | 11 | 8 | 5 | 4 | 4 | 2 | 2 | 2 |
| South Atlantic | 20 | 22 | 9 | 9 | 10 | 4 | 5 | 5 | 2 | 3 | 2 | 1 | 1 | 1 | [2] 0 | 1 | [2] 0 | [2] 0 |
| East North Central | 48 | 33 | 26 | 37 | 23 | 16 | 28 | 15 | 11 | 22 | 11 | 7 | 14 | 6 | 5 | 8 | 4 | 2 |
| East South Central | 5 | 5 | 2 | 1 | 3 | 1 | [2] 0 | 1 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 | [2] 0 |
| West North Central | 21 | 13 | 9 | 13 | 6 | 3 | 8 | 2 | 1 | 3 | 1 | [2] 0 | 2 | [2] 0 | [2] 0 | 1 | [2] 0 | [2] 0 |
| West South Central | 9 | 10 | 6 | 3 | 3 | 3 | 1 | 1 | 2 | 1 | 1 | 1 | [2] 0 | 1 | 1 | [2] 0 | [2] 0 | [2] 0 |
| Mountain | 45 | 34 | 41 | 34 | 25 | 31 | 22 | 16 | 21 | 16 | 10 | 15 | 11 | 7 | 11 | 6 | 3 | 8 |
| Pacific | 135 | 87 | 140 | 112 | 74 | 97 | 89 | 56 | 82 | 59 | 33 | 54 | 22 | 11 | 21 | 8 | 3 | 13 |
| United States average | 45 | 32 | 22 | 33 | 22 | 15 | 24 | 14 | 13 | 17 | 9 | 8 | 8 | 3 | 4 | 4 | 1 | 2 |

[1] Derived from the gross load formula $W = C(L + 40)$ in which $W$ is the total weight of the vehicle in pounds, or the weight of an interior group of axles, and $L$ is the distance in feet between the first and last axle of the vehicle, or of any interior group of axles.
[2] Less than 5 per 10,000.

and last axle of the vehicle, or of any interior group of axles. *C* is a measure of the load concentration and it is generally thought that a value of *C* greater than 750 is excessive. Thus the trend in the frequency of *C* values above 750 may be used as an index of the trend in the practice of excessive loading.

Table 10 gives the frequency of trucks and combinations with various values of *C* in 1945, 1944, and 1942. Heavier load concentrations were most frequent in the Pacific region with the Middle Atlantic region second. There was a steady increase in the frequency of heavy load concentration and in each of the six groups shown in the table the heavy concentrations were approximately twice as frequent in 1945 as in 1942.

(*Referred from p. 252*)

## APPENDIX.—SPECIFICATIONS FOR COTTON FABRIC FOR USE IN ROAD CONSTRUCTION

Cotton fabric used for the reinforcement of bituminous surface treatments shall meet the following specifications.

### GENERAL REQUIREMENTS OF THE FABRIC

The fabric for use in bituminous surface treatments shall be free from avoidable imperfections of manufacture or other defects which may affect its appearance or serviceability.

### RAW MATERIAL REQUIREMENTS

The fabric shall be made of raw cotton, cotton waste, or mixtures of raw cotton and cotton waste, from cotton grown and/or manufactured in the United States, of sufficient quality to obtain the fabric strength and other requirements of serviceability indicated herein.

### YARN REQUIREMENTS

(*a*) Ply—the yarn shall be two-ply.
(*b*) Twist—the twist in the two-ply yarn shall be such as to give what is known in the trade as a "balanced twist."
(*c*) Sizing—no sizing shall be applied to the yarn.
(*d*) Count and Strength—the yarn shall have a count and strength sufficient to make a fabric which will meet the specifications.

### DETAILED REQUIREMENTS OF THE FABRIC

(*a*) Weave—the weave shall be plain.
(*b*) Sizing—no sizing shall be applied to the fabric.
(*c*) Length of Rolls—a roll shall consist of a "cut" not shorter than 40 yards and not longer than 120 yards.
(*d*) Construction, etc.—the thread count, weight, width, and breaking strength of the various types of fabrics shall be as shown in table 1, except as noted in the tolerances.

### TOLERANCES

(*a*) Thread Count—a total plus or minus tolerance of two threads per 5 inches in a combination of warp and filling will be permitted.
(*b*) Width—a tolerance of plus or minus 1 inch from the width specified will be permitted.
(*c*) Breaking Strength—the combined strength of the warp and filling in the fabric shall equal or exceed the combined strength of these elements given in the above table and neither element shall be more than 10 percent under the requirements.
(*d*) Weight—a tolerance of plus or minus 5 percent will be permitted.

Table 1.—*Construction specifications for cotton fabric for use in road construction*

| Designation | Weight per square yard | Thread count per inch | | Width [1] | Minimum average breaking strength (grab method) | |
|---|---|---|---|---|---|---|
| | | Warp | Filling | | Warp | Filling |
| | *Ounces* | | | *Inches* | *Pounds* | *Pounds* |
| A-1 | 5.30 | 12 | 12 | 90 | 45 | 45 |
| A-2 | 5.30 | 12 | 12 | 82 | 45 | 45 |
| A-3 | 5.30 | 12 | 12 | 74 | 45 | 45 |
| B-1 | 4.25 | 9 | 9 | 90 | 35 | 35 |
| B-2 | 4.25 | 9 | 9 | 82 | 35 | 35 |
| B-3 | 4.25 | 9 | 9 | 74 | 35 | 35 |
| C-1 | 3.20 | 7 | 7 | 90 | 25 | 25 |
| C-2 | 3.20 | 7 | 7 | 82 | 25 | 25 |
| C-3 | 3.20 | 7 | 7 | 74 | 25 | 25 |

[1] The widths of 74, 82, and 90 inches are intended for use in surfaces 18, 20, and 22 feet wide, respectively, thus providing that the surface will be covered with three strips of fabric with laps of approximately 3 inches.

### METHODS OF SAMPLING AND TESTING

(*a*) Sampling—not less than one sample, at least 1 yard in length and the full width of the fabric, shall be taken at random from each 1,000 yards or fraction thereof, except when the shipment is over 10,000 yards, in which case at least one sample shall be taken from each one-tenth of the shipment.
(*b*) Testing—Federal Specification CCC–T–191, Textiles; Test Methods, of the issue in effect on date of invitation for bids, wherever practicable, shall be followed.

### PACKING AND MARKING

(*a*) Packing—the fabric shall be shipped in rolls not to exceed 120 yards per roll and shall be covered with material so as to insure acceptance by common or other carrier, for safe transportation, at the lowest rate, to the point of delivery.
(*b*) Marking—unless otherwise specified, shipping containers shall be marked with the name of the material, the style, the width, the quantity contained therein, the name of the contractor, and the number of the order.

# *PUBLICATIONS of the PUBLIC ROADS ADMINISTRATION*

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. As his office is not connected with the Agency and as the Agency does not sell publications, please send no remittance to the Federal Works Agency.

## *ANNUAL REPORTS*

Report of the Chief of the Bureau of Public Roads, 1931. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1932. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1933. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1934. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1935. 5 cents.

Report of the Chief of the Bureau of Public Roads, 1936. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1937. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1938. 10 cents.

Report of the Chief of the Bureau of Public Roads, 1939. 10 cents.

Work of the Public Roads Administration, 1940, 10 cents.

Work of the Public Roads Administration, 1941, 15 cents.

Work of the Public Roads Administration, 1942, 10 cents.

## *HOUSE DOCUMENT NO. 462*

Part 1 . . . Nonuniformity of State Motor-Vehicle Traffic Laws. 15 cents.

Part 2 . . . Skilled Investigation at the Scene of the Accident Needed to Develop Causes. 10 cents.

Part 3 . . Inadequacy of State Motor-Vehicle Accident Reporting. 10 cents.

Part 4 . . . Official Inspection of Vehicles. 10 cents.

Part 5 . . . Case Histories of Fatal Highway Accidents. 10 cents.

Part 6 . . . The Accident-Prone Driver. 10 cents.

## *MISCELLANEOUS PUBLICATIONS*

No. 191MP. . Roadside Improvement. 10 cents.

No. 272MP. . Construction of Private Driveways. 10 cents.

Highway Accidents. 10 cents.

The Taxation of Motor Vehicles in 1932. 35 cents.

Guides to Traffic Safety. 10 cents.

An Economic and Statistical Analysis of Highway-Construction Expenditures. 15 cents.

Highway Bond Calculations. 10 cents.

Transition Curves for Highways. 75 cents.

Highways of History. 25 cents.

Specifications for Construction of Roads and Bridges in National Forests and National Parks. 1 dollar.

Public Land Acquisition for Highway Purposes. 10 cents.

Tire Wear and Tire Failures on Various Road Surfaces. 10 cents.

Legal Aspects of Controlling Highway Access. 15 cents.

House Document No. 379. Interregional Highways. 75 cents.

## *DEPARTMENT BULLETINS*

No. 1279D . . Rural Highway Mileage, Income, and Expenditures, 1921 and 1922. 15 cents.

No. 1486D . . Highway Bridge Location. 15 cents.

## *TECHNICAL BULLETINS*

No. 265T. . . Electrical Equipment on Movable Bridges. 35 cents.

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Single copies of the following publications may be obtained from the Public Roads Administration upon request. They cannot be purchased from the Superintendent of Documents.

## *ANNUAL REPORT*

Public Roads Administration, 1943.

Public Roads Administration, 1944.

Public Roads Administration, 1945.

## *MISCELLANEOUS PUBLICATIONS*

No. 279MP. . Bibliography on Highway Lighting.

No. 296MP. . Bibliography on Highway Safety.

House Document No. 272 . . . Toll Roads and Free Roads.

Indexes to PUBLIC ROADS, volumes 15 and 17–23, inclusive.

## *SEPARATE REPRINT FROM THE YEARBOOK*

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

## *REPORTS IN COOPERATION WITH UNIVERSITY OF ILLINOIS*

No. 303 . . . Solutions for Certain Rectangular Slabs Continuous Over Flexible Support.

No. 304 . . . A Distribution Procedure for the Analysis of Slabs Continuous Over Flexible Beams.

No. 313 . . . Tests of Plaster-Model Slabs Subjected to Concentrated Loads.

No. 314 . . . Tests of Reinforced Concrete Slabs Subjected to Concentrated Loads.

No. 315 . . . Moments in Simple Span Bridge Slabs With Stiffened Edges.

No. 336 . . . Moments in I-Beam Bridges.

No. 345 . . . Ultimate Strength of Reinforced Concrete Beams as Related to the Plasticity Ratio of Concrete.

No. 346 . . . Highway Slab-Bridges with Curbs: Laboratory Tests and Proposed Design Method.

No. 363 . . . Study of Slab and Beam Highway Bridges.

## *UNIFORM VEHICLE CODE*

Act I.—Uniform Motor-Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor-Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor-Vehicle Civil Liability Act.

Act IV.—Uniform Motor-Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinance.

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A complete list of the publications of the Public Roads Administration classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to Public Roads Administration, Federal Works Bldg., Washington 25, D. C.