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# FEDERAL INFLUENCE AND AUTHORITY

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If today all the maintenance-of-way forces were taken simultaneously from the railroads, how long would rail transport continue to function? Certain fast schedules necessarily would be abandoned at once. On some lines for a short time, and on others for a longer period, a pretense of service would remain, but it is a matter of common understanding that our whole scheme of rail transportation is dependent upon continuous and adequate maintenance. A comparison between the physical condition of all of the major lines when first laid down, and now, proves the potentiality that lies within what accounting designates as maintenance, reconstruction and new construction. But these from the transportation viewpoint are all a part of a process. We have had a long enough experience now to get the picture that the furnishing of rail transportation facilities to large areas and over long mileages is not an operation defined by time limits or fixed financial expenditures, but is rather a never-ending process of repair and renewal, of constantly improved facilities, of nothing permanent but the general location and the growth of the demand for service. The process by which rail transportation has been brought to its present state of development presents a parallel to the highway situation. In detail there is much divergence, but the outstanding difference lies in the way the rolling stock has been placed upon the roadways. Rolling equipment was only put in service by the railways after the roadways designed for it were ready. It was controlled in weight, number and speed.

Motor vehicles were put in service on highways that, if improved within any reasonable meaning of the term, had been built to provide for a totally different kind of equipment and power. Over the period of the last ten to fifteen years, the traffic upon the highways as a whole, relative to their capacity, has not been controlled in weight, number or speed. The rising flood of motor vehicles has presented a decade of emergency conditions for highway administrators and engineers to meet. As the data for this article have been brought together, they have developed a far deeper appreciation of the actual accomplishments of these officials and particularly of the intelligent efforts of the state highway departments.

The United States has become the leading exponent of quantity production through standardized methods and designs. The public does not look questioningly beyond that production which springs from new materials and complete processes, but the today's quantity and duality service of highways with its availability to the far-reaching dimensions of the physical nation is not one of these. Rather it is the product of maintenance. It is the result of intelligent, constant effort to salvage, improve and extend facilities rapidly. Wholly new construction has been a large factor, true, but itself relies wholly upon adequate maintenance - maintenance in its newer conception, which now starts even before the contractor has left the job.

Maintenance Impulses - The efficient functioning of the state highway departments and the annual income from the motor vehicle user - license fees and gas tax - are the foundations under this modern highway service. The federal highway legislation has been a powerful force in establishing and holding to adequate and continuous maintenance as a first principle of highway administration. The distribution of war surplus trucks, tractors, repair plants, spare parts, incidental tools and materials, all in generous quantities, to the states, equipped the highway departments and did more than any other one thing to establish highway maintenance quickly on an effective nation-wide basis. The research and investigation, both physical and economic, of highway design and utilization have provided the knowledge upon which to develop a more effective maintenance technic. While the methods of keeping maintenance cost records are not yet fully informative or standardized over sufficient areas, nevertheless highway administration has progressed to a very definite recognition that two considerations have the greatest influence in determining the limitations of roadway types and new construction or reconstruction policies. These are the adequacy and the annual cost of highway service. The efficiency of highway administration, in a constantly increasing degree, will be measured in terms of these two factors. Their correct application will properly balance the annual program of maintenance, new construction and reconstruction.

Just what would have been the history of development of highway transport had there been no World War is difficult to visualize. What actually happened was so sudden and so extensive that the demands for serviceable highways could not be and were

not met by new construction. In fact, highways t
improved up to the prevailing standard and were t
ably adequate were so seriously damaged during 19
immediately following years as to convince the pu
entirely failed. Had this been true or had it be
through intensive and well-organized maintenance
to raise to a higher state of improvement much of
faced mileage, there would not be in use today a
percentage of the roadways which are carrying a h
stantly growing traffic. The potentialities of m
tenance and betterment were not understood becaus
enced prior to 1919.

Maintenance Needs - The graph, Fig. 1, shows the
registration of motor vehicles and the increase i
of surfaced roads. In these figures, credit is g
roads reported as surfaced by states and counties
included many miles of natural sand, clay or grav
and many more miles that, like Topsy, just grew w
gent direction, conception or efficient expenditu
national dependence upon maintenance is convincin
the separation of this total mileage into the sur
now in service, Fig. 2. These two graphs illustr
and the response. In no similar length of time h
or any private agency provided physical works of
of the highway mileage now in service. This fact
incorrect conclusion that we approach a lessened
program. The opposite is true. The whole highwa
rests on continuous maintenance, but a large perc
surfaced mileage is not economically and not secu
service.

Whether long mileages of low-cost roads, s
or reconstructed roads are or have been the corre
solution, is not a question. When a whole nation
to wheels driven by everywhere available and heed
supplies of low-cost gasoline, it wants and will
place to go. Parking space alone for cars manufa
about all the mileage the construction of federal-
supplies:

| Year | Cars Manufactured (Allowing 20 Feet per Car) in Miles | Miles of Federal-Aid Road Completed |
|---|---|---|
| 1919 ..... | 7,330 | 160 |
| 1920 ..... | 8,440 | 1,510 |
| 1921 ..... | 6,050 | 5,788 |
| 1922 ..... | 9,680 | 10,247 |
| 1923 ..... | 14,890 | 8,820 |
| 1924 ..... | 13,160 | 8,620 |
| 1925 ..... | 15,750 | 11,328 |
| 1926 ..... | 16,000 | 9,417 |

The gasoline used at the rate of 450 gal. per year per car would fill a lake two miles square and ten feet deep. The horsepower developed by this lake of gasoline and transmitted as pushing and abrading forces must be absorbed by the surfaces of our roads. Their physical structure receives the pounding of traffic with impact forces multiplying the actual weight many times.

In addition there are the rupturing stresses of expansion and contraction from thermal and moisture changes, the wash of storm water, the waste of the wind and the weakening and deterioration of materials through heat, cold and moisture. All of these have been more or less definitely measured. The warping or curling of a concrete slab roadway between the day and night temperatures may lift the slab from support of its subgrade alternately at the center and at the edges. Too soft asphaltic tops are rolled out of shape under heavy loads. The kick of motor wheels and the wind waste binder and body of gravel and waterbound macadam surfaces to fields and side ditches. Storm water cuts out embankments and subgrades, tears viciously at side ditches and piles debris against culverts and bridges. The mud-bottom streams common to the agricultural areas may deepen 15 to 20 ft. in one storm at bridge foundations.

Traffic Distribution Complication - Traffic grows apace. The public little realizes the amount of service the more heavily traveled highways are rendering. Both in numbers and tonnage the totals are astonishing. But the problem of maintenance would be greatly simplified if traffic were more evenly distributed. These facts are well illustrated by the summaries from recent transport surveys in the several states, Table I.

TABLE I - Average Daily Traffic for the Total Mileage of State Highway Systems

| State | State Highway System Mileage | Per Cent of Total Rural Mileage | Average Daily Motor Vehicle Traffic. Total | Trucks |
|---|---|---|---|---|
| Maine (1924 summer) | 1,680 | 7.1 | 1,044 | 94 |
| New Hampshire (1926 summer) | 1,454 | 11.3 | 916 | 51 |
| Vermont (1926 summer) | 1,043 | 7.2 | 702 | 41 |
| Connecticut (1923) | 1,114 | 7.2 | 1,018 | 147 |
| Pennsylvania (1924) | 10,274 | 11.0 | 635 | 57 |
| Ohio (1925) | 11,000 | 13.0 | 538 | 51 |
| Cook County, Ill. (1924 summer) | 418 | 25.0 (Approximate) | 2,371 | 146 |

Generalizations and averages are deceptive. This is particularly true in states like Ohio and Pennsylvania which have a very large total mileage under the jurisdiction of the state highway department. The maintenance problem becomes very different when a main route is considered, even though long distances are included:

Average Daily Traffic for Main Routes

Ohio

Chicago - Buffalo (U. S. 20) 157 miles
Conneaut, Ohio (Eastern State line) to Fremont (where routes divide) average daily traffic 2,450.

National Road (U. S. 40)
Average daily traffic 1,750 (159 miles from Brandt east to the Pennsylvania line; The section west of Brandt to the Indiana line was unimproved).

Dixie Highway (U. S. 25) from Toledo to Cincinnati, 215 miles. Average daily traffic 1,700.

Pennsylvania

Lincoln Highway (U. S. 30)
Trenton to Pittsburgh, 285 miles, average daily traffic 1,780.

U. S. Route 1
Portland, Maine to Washington, D. C., 608 miles, average daily traffic 4,200.

But even main route traffic is not a true indication of the maintenance problem. The intensive problem of providing and keeping in repair adequate highways is that of the gateway - the roads which provide the ingress and egress for our large cities and carry the traffic within what may properly be called the metropolitan areas, covering a radius of forty or fifty miles from the focal points of large population centers. The gateway problem on main highway routes is the big highway problem, Tables II and III.

TABLE II - Average and Maximum Daily Traffic on State Highways Near the Gateways of the Larger Pennsylvania Cities

| City | Number of State Routes | Average Daily Traffic: Motor Trucks | Average Daily Traffic: Passenger Cars and Motor Trucks | Maximum Daily Traffic |
|---|---|---|---|---|
| Philadelphia .... | 13 | 4,938 | 47,000 | 123,500 |
| Pittsburgh ..... | 9 | 2,491 | 19,700 | 52,760 |
| Scranton ..... | 5 | 1,762 | 14,000 | 52,460 |
| Harrisburg ..... | 6 | 2,424 | 22,100 | 57,100 |

TABLE III - Average and Maximum Daily Traffic on State Highways Near the Gateways of the Larger Ohio Cities

| City | Number of States Routes | Average Daily Traffic: Motor Trucks | Average Daily Traffic: Passenger Cars and Motor Trucks | Maximum Daily Traffic |
|---|---|---|---|---|
| * Cleveland ..... | 17 | 2,907 | 32,938 | 75,895 |
| ⊥ Cincinnati ..... | 11 | 2,201 | 15,739 | 36,479 |
| Toledo ..... | 10 | 2,254 | 21,612 | 49,941 |
| Columbus ..... | 11 | 1,428 | 19,332 | 44,860 |
| Akron ..... | 9 | 2,136 | 18,561 | 42,874 |
| Dayton ..... | 12 | 1,688 | 19,972 | 46,160 |

* Includes East Cleveland, Lorain and incorporated suburban areas.

⊥ Includes incorporated suburban areas, but does not include traffic crossing the Ohio River.

Maintenance Factors - While maintenance is a difficult, unending task in every state, the combinations of the conditions which are the most effective in the tearing down processes are not found universally. The states on both sides of a line from Boston, Mass., to New York City, to Chicago, and the cities of the Mississippi valley extending to the Missouri or just beyond on the west and to the Ohio River on the south, including the state of Missouri, present the most difficult maintenance problems. There is a wide range of conditions in this area, but within this roughly defined portion of the United States the combinations of factors are formed that are the most disastrous to our highways. Here are found, together, thermal ranges from 100 deg. F. to 30 deg. below zero; long periods of alternate freezing and thawing; very finely divided subgrade soils; the heaviest traffic, both in weight and number; and rain, snow and ice for long continuing periods. Mix all these elements together and they are warranted to necessitate the most difficult and most expensive road maintenance. Outside of the area described, all of these factors are not found together in any considerable area, or, if found, their degree of "badness" is less.

Given any type of road, the factors listed form the worst possible combinations to meet. Ten years ago, however, there were only small mileages of the paved types of roadways, confined almost wholly to the eastern states, and these had not been designed for the wartime truck loads. The surfaced mileage consisted almost wholly of macadam - waterbound, surface treated or penetration - and gravel, varying between wide limits of stone content, from pebbles down to the sand clays - natural mixes. Such roadways became quickly inadequate with the great increase of motor traffic. But they as well as large mileages of unsurfaced soil roads, much of which were not superficially well drained, had to be held in service. Such a serious emergency called for much larger and more vigorous maintenance organizations, and those states with well-established highway departments quickly expanded their maintenance forces. The newer highway departments came into being with maintenance as a major function. With few exceptions, all the state organizations grasped quickly the size and seriousness of the problem confronting them. They attacked the problem with technical skill and broad vision and quickly crystallized a revolutionary administrative policy that has made possible the extensive mileage of highways in service today.

This better policy finds it best expression in the determined efforts of the highway officials, state and local, to keep the highways in usable condition without accepting or excusing defect because of type or traffic.

Federal Influence - Previously, if judged by today's standards, no roads regardless of type had been adequately maintained over sustained periods under local jurisdiction. The fact was recognized and criticized vigorously. But effective measures to establish state control and to cure the lack of competent engineering direction, in a large majority of the states, were being even more vigorously, and certainly more effectively, opposed by selfish interests and by political demagogues. Just at this crucial time came the first federal highway legislation, the Act of 1916. Two outstanding principles of highway administration were written into this legislation as requirements contingent upon the acceptance by the states of the cooperation in road improvement offered by the federal government. These are:

> That each state should have established an adequate highway department: and
>
> That each state having received federal funds is obligated to maintain in satisfactory condition the roads so built.

In 1916, one-third or more of the states had no highway department. The road work was wholly under local control. Nearly another third had organizations with limited authority or insufficient funds. Thus as late as 1916, at least two-thirds of the states were not effectively organized to construct and to maintain their main highways.

A fatal weakness in the financing followed under local control was the lack of maintenance funds. This was particularly true when county or district bonds were issued to undertake a relatively ambitious program of new construction. Communities heavily in debt saw their roads rapidly deteriorating and lost faith. They had believed in permanent roads and failed to provide maintenance funds. The federal aid road legislation of 1916 provided:

"Sec. 7. To maintain the roads constructed under the provisions of this act shall be the duty of the states, or their civil subdivisions, according to the laws of the several states.

If at any time the Secretary of Agriculture shall find that any road in any state constructed under the provisions of this act is not being properly maintained he shall give notice of such fact to the highway department of such state; * * *."

This legislation required the assent of the state through its legislature to its terms. Highway legislation in all the states quickly followed. Thus within a two or three-year period every state had enacted additional highway laws. Some, it is true, were so meager they barely met the federal requirements, but even these contained the essential provision for a state department, and fixed responsibility for maintenance of road projects on which federal funds were used. As the motor vehicle had by 1916 increased to such numbers that a considerable revenue could be obtained through license fees, this revenue was quite generally dedicated first to maintenance. Very soon, in 1919, the first tax on gasoline appeared, which has proven to be such a popular method of raising additional revenues that all but two states now tax gasoline, varying from 2 to 5¢ per gallon.

To what extent the federal legislation has held these revenues from the road user in large measure for road purposes is known only to the highway officials, who have fought off attempted diverting of these funds for other purposes.

Highway Expenditures - The following schedules, Tables IV, V and VI, are taken from data collected by the Bureau of Public Roads. For state funds, they are relisble. For the local funds, they are gathered largely from original sources and are as accurate as the accounting records of the local governments. These vary between wide limits and extreme accuracy is not claimed, but the totals present a reliable survey.

These schedules show: First, the division of a billion-dollar road program between state and local control and the tendency toward, rather than away from, greater state control; second, the increase in maintenance expenditure; third, that maintenance is absorbing 30 per cent of the total funds plus equipment costs chargeable; fourth, that state highway maintenance absorbs about 20 per cent plus equipment chargeable; and fifth, that the road user is paying a constantly increasing percentage of the total cost.

TABLE IV - Highway Funds, Total Expenditures

| Year | Total Highway Expenditures | State | Local |
|---|---|---|---|
| 1923 ..... | $1,000,000,000* | $447,362,358 | $552,637,642* |
| 1924 ..... | 1,181,521,115 | 605,665,207 | 575,855,908 |
| 1925 ..... | 1,288,939,707 | 649,125,101 | 639,814,606 |
| 1926 ..... | 1,053,440,210 | 621,744,210 | 431,696,000 |
| 1927* ..... | 1,136,257,055* | 658,958,055 | 477,299,000* |

*Estimated.

These totals are used for construction, maintenance and miscellaneous, as shown in Table V. The miscellaneous item includes payments of interest and principal on bonds and equipment. The latter item is largely for maintenance equipment.

The contribution from the motor vehicle user in license and gas taxes alone, and used for the general purposes shown in Table V, was, for 1926, Table VI, nearly $460,000,000.

Federal Contract Methods - There is a total of 287,900 miles in the state highway systems. The average cost of maintenance for 1926 was approximately $436 per mile. This figure is not indicative of maintenance costs for any types of roads, but does indicate the average cost to the nation of each mile of the state highway systems. The federal highway system includes 185,772 miles which run coincidently nearly to this extent with the state highway systems. The maintenance requirement of the federal legislation would offer perhaps the greatest opportunity for friction in the cooperative relationships were it not for the fact that the state and federal forces have come to look at maintenance from exactly the same viewpoint.

As soon as construction is completed on federal-aid projects, the maintenance inspections by the field engineers of the Bureau of Public Roads begin. There are twelve federal districts, each with a district engineer in charge. The engineers who under the supervision of the district engineers work with the highway departments, in general, are located in the states. They are constantly on the road and know in intimate detail the projects during their construction and the later maintenance. Last year in their inspection of federal highway projects, the engineers of the bureau traveled 1,723,000 miles, the greater proportion of which was on the federal highway system. The force is stable. In a number of states the federal engineers have been a large factor in preserving continuity of construction and maintenance policies because of a constantly shifting and changing state department. Federal-aid projects thus are constantly inspected by engineers who know them. Copies of inspection reports constitute a memorandum of needed repairs for the state.

TABLE V - Highway Funds Classified Expenditures

| Year | State | | |
|---|---|---|---|
| | Construction | Maintenance | Miscellaneous |
| 1923 ..... | $279,245,875 | $75,329,158 | $92,787,325 |
| 1924 ..... | 381,080,058 | 104,806,557 | 119,778,592 |
| 1925 ..... | 386,966,871 | 119,303,560 | 142,855,670 |
| 1926 ..... | 381,222,337 | 125,617,313 | 144,904,560 |

Cont'd.

| Year | Local | | |
|---|---|---|---|
| | Construction | Maintenance | Miscellaneous |
| 1923 ..... | Data not available | | |
| 1924 ..... | $255,949,803 | $193,372,152 | $127,533,843 |
| 1925 ..... | 264,965,764 | 196,573,516 | 178,775,326 |
| 1926 ..... | Data not available | | |

TABLE VI - Highway Funds, Sources of Revenue

| Year | State | | | |
|---|---|---|---|---|
| | Motor Vehicle Tax | Gas Tax | Property Tax | Bonds |
| 1923 | $147,675,966 | $15,872,844 | $24,348,378 | $88,786,784 |
| 1924 | 174,816,973 | 47,810,615 | 18,282,878 | 101,653,327 |
| 1925 | 199,845,163 | 89,328,340 | 21,489,004 | 141,402,022 |
| 1926 | 224,551,631 | 134,303,154 | 18,278,994 | 103,846,301 |

Cont'd.

| Year | Local | | | |
|---|---|---|---|---|
| | Motor Vehicle Tax | Gas Tax | Property Tax | Bonds |
| 1923 | .....* | .....* | .....* | .....* |
| 1924 | $26,856,176 | $16,971,402 | $376,787,861 | $157,536,944 |
| 1925 | 46,545,445 | 24,833,979 | 412,825,227 | 144,413,116 |
| 1926 | 57,156,282 | 43,609,479 | .....† | .....† |

* No data secured for local revenues 1923.
† Data in process of collection.

Twice each year the individual reports of maintenance conditions are summarized at the Washington office of the bureau. A project listed as unsatisfactory is followed up and the black mark only removed when, as shown by actual field inspection, it is again in satisfactory condition. On the first of January, 1927, the semi-annual inspection report covered 57,408 miles of projects then under maintenance. This included all but eight miles of the total projects built with federal aid. Of this total, 55,756 miles were reported in a satisfactory condition of maintenance, and 1,652 miles, or about 2.8 per cent, were in an unsatisfactory maintenance condition.

Future Problems - Maintenance, however good, fails when traffic passes the maximum limit for the type. So the big problem now, after ten years of building federal projects, is to raise the roadways to a type that can be maintained under the enormous increase in traffic.

In this connection, Figs. 1 and 2 show the existing facts, but they are incorporated rather to show tendencies, since in a work of the magnitude of highway improvement the direction in which growth is taking place is at least equally important with the presently existing situation. Fig. 1 shows how much greater has been the acceleration of the individual in equipping himself with motor vehicles than of the nation in providing itself with adequate highways.

An important function of the federal maintenance requirement - perhaps it may prove to be the most important - is that of determining the point when reconstruction or the stepping up to higher types of surface is needed. Already the future program of federal-aid projects in one large state is based upon the maintenance records. These records point out clearly the difference between satisfactory maintenance and satisfactory service. When adequate maintenance efforts fail to produce satisfactory service then the type must be changed.

When the war ended we were left with a large amount of surplus war equipment, some in this country and a great deal abroad. Congress provided for the distribution of such surplus as was suitable for road building purposes to the states. This produced two major effects. States which up to that time had not been able to establish adequate maintenance because of lack

of means had at once placed in their hands the equipment which could be used for this purpose, and because it came as a free distribution the public accepted without much protest its utilization in numbers on the highways. The second effect was equally important. The use of the equipment enabled the state highway departments to hold the existing roads in reasonably serviceable condition while the construction programs were being put under way. Possibly nothing added more to the support of the highway departments than the widespread betterment of conditions made possible not alone through the equipment distributed by the federal government, but by reason of the fact that the public became accustomed to the possession and use of a large amount of equipment by the state departments. There were distributed to the states approximately 36,000 motor vehicles and large quantities of spare parts, explosives, hand-tools and other surplus that could be used advantageously for road maintenance. In all, 753,000,000 lb. of material were distributed, the value of which was estimated at $222,000,000. There was considerable waste of course in an operation of a purely salvaging nature, but the foundation of the maintenance equipment in all but a very few states has been this war surplus, and through its use the nation obtained a return many times greater than could have been obtained by any other disposition.

Maintenance records have not as yet been reduced to a comparable basis between the states. A committee of the American Association of State Highway Officials is working toward this end, but to establish uniform records is far less important than to establish adequate records, and adequacy in this sense means the actual expenditures co-ordinated with the quality of service, the amount and kind of traffic, and the division of expense between roadbed and road surface. For example, the cost for a certain stretch of road in 1926 is reported as $3,714. Here the records were separated, however, and the cost of the pavement maintenance per mile was $563. Another and longer route cost an average of $1,076 per mile to maintain, but the cost of pavement maintenance was $233. Here are the actual costs on which the pavement costs themselves are too high, but they are not relatively nearly so high as the roadbed costs. These point unfailingly to lack of adequate width and poor side ditch and shoulder construction.

Research has pointed out the weak points of our roads and has to a degree determined the capacity of given types of construction. Conditions vary so widely, however, that maintenance costs and service records are necessary to check against proposed designs no matter how perfect theoretically.

In summary it may be said that the technic of maintenance, the handling of equipment, the use of materials, have been developed to a point much further advanced than the economic considerations, but there is no excuse now for not taking full advantage of the information furnished from maintenance records upon which to determine a really scientific administrative plan for administering highway funds. The use of the mechanical tabulating machines has made possible the utilization of quantities of data because they quickly and economically sort, classify and summarize the contained information. The highway information of the future will be gained from such studies, and sound policies of highway administration will be founded upon maintenance records both of cost and adequacy of service.

It would not do to conclude this article with the chance of having produced an attitude of composure. Our highway system is decidedly in an unbalenced status. There were added to the mileage of state roads last year nearly 13,000 miles, due undoubtedly to the desire to get these roads under state maintenance and state construction, which indicates the political strength of this urge. There are now 287,900 miles in the state highway systems, of which 163,000 miles, or 57 per cent, are surfaced. Of this 57 per cent, 109,000, or 67 per cent - two-thirds of the entire surfaced mileage on the state systems - is of what may be termed transient types: that is, before economic maintenance results they must be largely lifted to higher types, or the present types greatly improved.

The local road situation gives even greater reason for concern. Of the 2,751,000 miles remaining after taking out the state mileage, 376,000 miles are surfaced, or 14 per cent. Of this surfaced mileage 347,000 miles, or 92 per cent, are of the same types as those listed as transient for the state systems: that is, they include the sand-clay, gravel and water-bound macadam surface types.

These facts are certainly more convincing of our utter dependence upon maintenance than a volume of argument.