D. Effect of Physical Condition of Road on Recurrence of Accidents
Accidents reported to the Pennsylvania Department of Highways, during 1926, were found to include 53 per cent occurring on straight road, 26 per cent on light curve, and 21 per cent on sharp curve

Plans for 103 selected sections of road were assumed to be representative of the State highway system and included 66 per cent tangent, 31 per cent of curvature under 10 degrees and 3 per cent of curvature 10 degrees or more.

In the analysis of accidents with relation to horizontal curvature, the accident rate is found to be—

Tangent	1 00
Light curve	1 05
Sharp curve	8 75

Making a similar analysis for gradient it was found that 83 per cent of the line is under 6 per cent grade and 17 per cent of the line 6 per cent or more, and the relative accident rate—

Light grade	1 00
Heavy grade	5 08

TRAFFIC SURVEYS, AND THEIR BEARING ON THE FINANCING OF ROAD BUILDING PROGRAMS[1]

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Highway systems should provide satisfactory transportation service for the movement of people and commodities by the most direct, practicable routes between the various sources of traffic in a given area The expenditure of public funds for the improvement of the several classes of highways should be based primarily on the traffic that now travels and, in the future, is expected to travel on state, county and township roads

The first basic principle of highway production management is that the improvement of each of the four groups of highway systems, national, state, county and township, should follow an established plan of development in which the improvement of various sections of each highway system, the character of the improvement, and the investment of public funds in each project should be based on present and expected future

[1] This paper was arranged for by the Committee on Highway Traffic Analysis Conclusions and recommendations are those of the author and have not been endorsed by the committee

traffic use, modified by the various physical and engineering factors which frequently determine the selection of specific types of construction

A policy of over-development of a highway system is more dangerous than a conservative improvement policy based on the stage construction principle More attention should be directed to the formulation of effective legislative policies which will scientifically control the determination of highways requiring improvement, their location, type of construction, and provide equitable methods of financing highway improvements by state, county and local highway authorities

The second basic principle of highway management is the establishment of a highway budget, which involves the determination of the amount of funds necessary to scientifically improve the four road systems over a definite period of years, the annual funds required, and an equitable distribution of the cost of the improvement program among the sources of highway income

There is no satisfactory reason why state and county highway departments cannot establish a definite plan of improvement, based on traffic and engineering facts, for periods of at least five years and preferably for ten years Such a plan will insure continuity of development, the improvement of routes in the order of their traffic importance, the elimination of political influence, which in many cases dictates the betterment of a highway or section of a highway, the expenditure of public funds on projects which should be completed first, and the prevention of either over-development or under-development of a highway or section of a highway system

We have passed the period in highway development when individual judgment, political pressure or any factors, other than traffic, engineering and financial facts, should be accepted as a basis of determining highway betterments The facts which should guide the establishment of a program of improvement can be ascertained at a comparatively small cost, and the various jurisdictions responsible for highway improvements should be required to establish a definite program prior to the appropriation of funds

The absence of a definite plan is particularly serious in the congested traffic areas surrounding centers of population In the regional traffic areas of New York, Philadelphia, Chicago, Cleveland and the larger centers of population are found the greatest density of traffic and the most serious congestion sections on the principal traffic routes, as well as the most difficult and expensive highway engineering problems that require immediate solution to provide efficient and safe highway transportation The complicated highway and traffic problems in these areas include the location and construction of new arterial routes, acquisition of new and widening of existing highway right of way,

widening of present road and street surfaces, new bridges and the reconstruction and widening of existing structures, double-deck roadways, grade separations at both railroad and highway intersections; parking lanes, vehicle storage areas off the traveled way, preservation of right of way for future highway developments, building set-back lines, traffic control and safety, distribution of the cost of the several classes of improvement, and other problems that challenge the traffic engineer, highway officials, economists and the public

Motor vehicle traffic facts from the highway transportation and planning surveys completed by the United States Bureau of Public Roads in cooperation with the several state and county highway departments in California, Connecticut, Maine, New Hampshire, Ohio, Pennsylvania, Tennessee, Vermont, and in the Chicago and Cleveland Regional Areas, show that traffic use and distribution on the highways of the several states have similar characteristics, the more important being as follows

1 The yearly increase of traffic on the rural highways of the several states is measured by the yearly increase of motor vehicle registration Highway traffic and motor vehicle registration in Connecticut, Massachusetts, Maryland, Maine, Michigan, New Hampshire, Ohio, Vermont and Wisconsin have increased at approximately equal rates The variations in industrial and agricultural development, in motor vehicle ownership, and in population, in the period of the surveys in each state, apparently, has had no effect upon the relationship between the rates of traffic increase on the highways and motor vehicle registration growth [2]

2 The greatest daily density of traffic is found on the highways adjacent to centers of population and motor vehicle ownership, and this traffic is predominantly local in character Of the 11,000 miles of the State Highway System of Ohio, 858 miles, 7 8 per cent of the mileage, carried 1,500 or more motor vehicles per mile per day, and 7,761 miles, 70 6 per cent, carried less than 600 vehicles per day, of which 4,180 miles carried less than 200 vehicles per day Of the 1,264 miles of national, state and county roads in the Cleveland Regional Area, only 20 miles, 1 6 per cent of the total mileage, carried 10,000 or more vehicles per mile per day, 365 miles, 28 9 per cent, 1,800 or more vehicles, and 569 miles, 45 0 per cent of the mileage, carried less than 700 vehicles per day [3]

3 Motor truck transportation on rural highway systems averages 10 0 per cent of total traffic

[2] Report of a Survey of Transportation on the State Highway System of Connecticut, 1926, New Hampshire, 1927, Ohio, 1927; Vermont, 1927; Pennsylvania, 1928

[3] Report of a Survey of Highway Traffic and Planning on the highways of the Cleveland, Ohio, Regional Area 1928

4 Daily motor truck traffic is small in volume on a large mileage of the rural highway system, and the daily volume of large capacity trucks is an unimportant part of total traffic On the Ohio State Highway System 7,981 miles, 72 5 per cent of the mileage, carried less than 60 trucks per day, of which 5,305 miles, 48 2 per cent, carried less than 30 trucks per mile per 24 hour day Of the 11,000 miles of state highways in Ohio, 10,289 miles carried less than fifteen 3 to 7½ ton trucks per mile per day, while only 94 miles carried forty or more trucks of 3 to 7½ tons capacity On the Connecticut State Highway System, 79 2 per cent of the motor trucks are ½ to 2½ tons capacity and only 11 7 per cent 5 to 7½ tons capacity

5 Two-thirds of the passenger car trips are less than sixty miles, and three-fourths of the motor truck trips are less than thirty miles

6 Long distance traffic is small in volume,and the facts supporting the improvement of rural highway systems clearly show that local traffic comprises a large percentage of total traffic on all highway systems, except on the highways of a comparatively few important tourist areas

The improvement of highways in the Cleveland Regional Area is primarily for the benefit of and necessitated by the volume of local traffic On fifteen main routes in Cuyahoga County only 2 4 per cent of the passenger car traffic crossed the County between points outside of Cuyahoga County and only 1 5 per cent traveled across the regional area These facts illustrate the lack of importance of through traffic in areas adjacent to large centers of population On the 11,000 miles of the Ohio State Highway System 10 2 per cent of the daily passenger car use was by vehicles owned outside of Ohio, while on the 1,454 miles of the New Hampshire State Highway System over 50 0 per cent of the total traffic consisted of foreign vehicles [4]

7 Of the total traffic on rural highway systems, approximately 80 0 per cent travels on the state highway system, which averages 10 0 per cent of the total rural mileage among the several states Of the 3,487,210,000 annual vehicle miles on the rural highway system of Pennsylvania in 1924, 68·3 per cent operated on state highways, which comprised 11 0 per cent of the 95,194 miles of rural roads, and 31 7 per cent of the use was on the county and township roads, comprising 89 0 per cent of the rural highway mileage The average daily density of traffic per mile on the rural highway systems of Pennsylvania was 635 on the state system, 306 on county highways, and 29 on township roads [5]

[4] Report of a Survey of Transportation on the State Highways of New Hampshire, 1927

[5] Report of a Survey of Highway Traffic on the Pennsylvania State Highway System, 1928

Of the 3,746,360,000 annual vehicle miles on the Ohio rural highway system, 57 7 per cent was on the 11,000 miles of the state highway system, 13 0 per cent of the 84,884 miles of the Ohio rural highways, 29 6 per cent on the county highway system, 27 1 per cent of the mileage; and 12 7 per cent on the township system, 59 9 per cent of the total rural mileage The average daily density of traffic per mile on the rural highway systems of Ohio was 538 on state highways, 132 on county highways and 26 on township roads

8 Traffic on the rural highway system is predominantly that of city owned passenger cars and motor trucks On the New Hampshire State Highway System 6 1 per cent of the use consisted of farm owned vehicles and the average trip 13 miles, in Ohio 12 4 per cent of the traffic and the average trip 12 miles, in Pennsylvania 7 1 per cent and the average trip 26 miles, and in Vermont 10 1 per cent, while the average trip was 12 miles

Of the 23,500,000 motor vehicles registered in the United States in 1927, 5,000,000 were farm owned vehicles. Although approximately one-fifth of the motor vehicles are farm owned vehicles, they are distributed over a considerably larger area than city owned vehicles and their use on the highway is less concentrated

9. On rural highway systems, based on present and expected future traffic during the next fifteen years, the construction of surfaces in excess of a width sufficient for two lanes of traffic, preferably 20 feet, is unnecessary, except on a very small mileage adjacent to the larger centers of population and a few of the major traffic routes connecting the larger cities of the country A corollary of this general rule is that the present acquisition of highway right of way in excess of 60 feet, under normal conditions, is unwarranted on the state highway system, except in a few areas of dense traffic With respect to the protection of right of way for future highway use, it is a more economical policy for the state to establish building set-back lines rather than to acquire right of way in excess of 60 feet, since the acquisition of additional width for future use usually requires an outlay of public funds, takes rural land out of production, and involves the state in maintenance expenditures for the additional unused right of way

10 Rural highway systems, beyond the zone of traffic influence of large cities, on an average thirty miles, do not and will not in the future carry large daily volumes of traffic On the Ohio State Highway System only 131 miles carried 2,500 or more vehicles per mile per day in 1925, 858 miles 1,500 or more, and 4,180 miles 200 or less vehicles per mile per day Only 24 0 per cent of the state highway mileage of Ohio required construction of concrete, brick or equivalent types of improvement in 1925 During the period of the next fifteen years approxi-

mately 5 0 per cent of the total rural mileage of the country will require major types of paved surfaces to satisfactorily serve traffic

11 Manufactured products constitute the largest percentage of goods hauled on rural highways In Connecticut manufactured products are 69 0 per cent of the total net tonnage, in Cook County, Illinois, 66 0 per cent, in Maine 55 1 per cent, in New Hampshire 52 1 per cent, in Ohio 46 6 per cent, in Pennsylvania 60 5 per cent and in Vermont 43 4 per cent Products of agriculture and animals comprised 16 4 per cent of the total net tonnage hauled on rural highways in Connecticut, 18 7 per cent in Cook County, 15 0 per cent in Maine, 14 6 per cent in New Hampshire, 21 9 per cent in Ohio, 19 9 per cent in Pennsylvania and 17 1 per cent in Vermont

Farms contribute but a comparatively small part of total motor truck haulage in the several states Of the several classes of origin of motor truck traffic, farms comprised on 7 5 per cent of the total loaded motor trucks on the highway system of Cook County, Illinois, 11 9 per cent in Maine, 5 5 per cent in New Hampshire, 12 7 per cent in Ohio, 7 8 per cent in Pennsylvania and 11 1 per cent in Vermont

The rural highway system of the United States comprises four road systems, national, state, county and township On January 1, 1927 the total mileage of rural roads was 3,000,190 miles, of which the national (Federal Aid) system was 186,227 miles, the state highway mileage, including the mileage of the national system, was 287,928 miles, and county and township roads 2,712,262 miles

On state highway systems 56 6 per cent of the mileage was surfaced with sand clay, topsoil, gravel or pavement, and on county and township roads 14 3 per cent was similarly improved Of the 2,712,262 miles of county and township highways, 387,005 miles were surfaced with sand clay, topsoil, gravel or paved surfaces, 598,803 miles improved to established grade and drained, and 1,726,454 miles unimproved or partly graded

The improvement in excess of a low type, "all weather" road of approximately 95 0 per cent of the rural highway mileage, which has no real traffic importance, cannot be supported from the viewpoint of either present and expected future traffic use, the influence of the improvement on farm marketing, or an increase in farm value resulting from highway improvements It is difficult to visualize the improvement of a considerable percentage of county highways or township roads with a surface superior to a low type, "all weather" road when traffic using these roads for a large part of the county mileage of the State of Ohio, a typical agricultural-industrial state, is less than 50 vehicles per mile per day, and on the township roads of the same state 29 vehicles per mile per day

The improvement of established roads serving a farm territory has

little influence on the value of rural land, compared with the major factors which establish the value of agricultural land The approximate differentials in farm value between road types resulting from highway improvement in a Wisconsin dairy county is less than $5 00 per acre for a concrete surface over a gravel surface and less than $3 00 per acre for a gravel surface over an earth road Similar relationships were found in several Iowa counties This small increment of values to rural farm land resulting from improved highways, if taxed to finance part of the cost of a highway improvement, requires the future replacement of the highway improvement from other sources of income For example, assume a paved surface adds $4 00 of value per acre to farm land within a one mile zone on each side of the road Assume further that this increase in value is absorbed by taxation to finance part of the total cost of the road improvement Fifteen or twenty years later the road is worn out and must be replaced Financing of any part of the replacement costs should not be assessed against the same farm land, since the replaced surface adds no new transportation value to the land

Based on traffic use and the influence of highway improvements on land values in regional traffic zones and in rural areas the following administrative control over highway systems and the financing of these systems is suggested

1 National and State Highway Systems

These highways, as a general rule, comprise the important traffic routes of a state, and their improvement is caused primarily by city owned motor vehicle traffic The state should have complete control over the construction and maintenance of this system Its improvement should be financed, primarily, from motor vehicle license fees and gasoline taxation A small contribution can be assessed against benefited property, over a large part of the state highway system, and a larger percentage of the cost assessed for state highway improvements in the suburban areas surrounding centers of population

2 Regional Highway Systems

Highway administration, construction and financing in the zones of traffic surrounding centers of population should be unified, including on this system the several counties which comprise the areas of regional traffic importance

The financing of highway improvements in these areas should be a combination of motor vehicle license fees, gasoline taxation, real property taxation and special assessments on benefited property Real property should contribute an equitable part of the cost of highway improvement since the value of business, residential or potential residential property, is materially

influenced by the location and character of road betterments The principle of decreasing influence of the road improvement on the value of abutting and zoned property adjacent to a highway improvement with increasing distance from the business center of these areas should be recognized in the distribution of special assessments

3 Rural Highway Systems

Rural counties of similar characteristics should be consolidated for purposes of highway improvement County lines are of no importance to traffic and constitute artificial jurisdictional barriers The grouping of counties into regional rural highway improvement areas will have the following practical results Competent engineering personnel can be employed to direct the improvement program of areas larger than one rural county at a comparatively small cost for each county included modern road improvement equipment, that is unwarranted in a low traffic rural county, can be purchased and used efficiently in a larger area, thus avoiding an unnecessary duplication of equipment among the several counties the total capital outlay for road improvement and the cost of maintenance would undoubtedly be less than present expenditures a better class of improvements would result from a consolidation into regional rural areas, and the highway improvement funds would be more wisely invested

The financing of rural roads, excluding the state highway system, in these areas of low traffic should be based on a combination of state contribution and local property taxation The allocation of state funds, admittedly, is not based on traffic use or the registration of motor vehicles in these areas, both of which are small, but on the social subsidy theory, and the taxation of real property on a general benefit theory The contribution of state funds should carry with it the right to control the general engineering policies of improvement to insure proper expenditure of state funds and a satisfactory improvement of the rural road system