PUBLIC ROADS

A JOURNAL OF HIGHWAY RESEARCH

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

VOL. 5, NO. 6 ▽ AUGUST, 1924

THE LACKAWANNA TRAIL IN PENNSYLVANIA—AS SAFE AS A ROAD CAN BE

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924

PUBLIC ROADS

A JOURNAL OF HIGHWAY RESEARCH

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

CERTIFICATE: By direction of the Secretary of Agriculture, the matter contained herein is published as administrative information and is required for the proper transaction of the public business

VOL. 5, NO. 6 AUGUST, 1924 H. S. FAIRBANK, Editor

TABLE OF CONTENTS

THE U. S. BUREAU OF PUBLIC ROADS

Willard Building, Washington, D. C.

REGIONAL HEADQUARTERS,
Bay Building, San Francisco, Calif.

DISTRICT OFFICES

DISTRICT No. 1, Oregon, Washington, Montana, and Alaska.
Box 3900, Portland, Oreg.

DISTRICT No. 2, California and Nevada.
Bay Building, San Francisco, Calif.

DISTRICT No. 3, Colorado and Wyoming.
301 Customhouse Building, Denver, Colo.

DISTRICT No. 4, Minnesota, North Dakota, South Dakota, and Wisconsin.
410 Hamm Building, St. Paul, Minn.

DISTRICT No. 5, Iowa, Kansas, Missouri, and Nebraska.
8th Floor, Saunders-Kennedy Bldg., Omaha, Nebr.

DISTRICT No. 6, Arkansas, Louisiana, Oklahoma, and Texas.
1912 F. & M. Bank Building, Fort Worth, Tex.

DISTRICT No. 7, Illinois, Indiana, Kentucky, and Michigan.
South Chicago Station, Chicago, Ill.

DISTRICT No. 8, Alabama, Georgia, Florida, Mississippi, South Carolina, and Tennessee.
Box J, Montgomery, Ala.

DISTRICT No. 9, Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.
Federal Building, Troy, N. Y

DISTRICT No. 10, Delaware, Maryland, North Carolina, Ohio, Pennsylvania, Virginia, and West Virginia.
Willard Building, Washington, D. C.

DISTRICT No. 12, Idaho and Utah.
Fred J. Kiesel Building, Ogden, Utah.

DISTRICT No. 13, Arizona and New Mexico.
242 West Washington St., Phoenix, Ariz.

TRAFFIC CONTROL AND SAFETY

A REVIEW OF EXISTING METHODS AND DEVICES FOR PROMOTING HIGHWAY SAFETY

By E. W. JAMES, Chief, Division of Design, U. S. Bureau of Public Roads

THE construction, maintenance, and administration of public highways has become the largest element in the program of public works in the United States. A density of traffic represented by a registration of fifteen and a quarter million motor vehicles in the United States presents a new administrative problem. The annual increase in traffic accidents with growing fatality to life and increasing loss and damage to property emphasizes the immediate and imperative need of effective steps toward traffic control and greater consequent safety to users of the road. The rapid production of additional improved mileage, the closing of open links, the betterment of bad sections and the resultant extension of long, unbroken routes of good roads, with the accompanying inevitable growth of long distance travel and touring by automobile, will certainly cause a corresponding increase in the danger attending highway travel.

This article will outline briefly the several aspects of the problem and indicate in general terms the advance so far made in the direction of traffic control and safety.

There are four fundamental considerations. First, there is the independent safety of the individual driver; then the common safety of passing drivers. Next is the question of safety for pedestrians, and finally there must be due consideration of the economic maintenance, care, and preservation of the road itself. No solution of the matter will be complete that fails to give fair consideration to any of these phases of the problem. The lines between them are not sharply drawn. Details of design and regulations accomplishing a satisfactory end from the point of view of the individual driver may offer at once an equally effective solution of the problems raised by passing traffic, and may serve also to protect the pedestrian. Control of traffic on behalf of the road surface will likewise promote the general safety of traffic by reducing speeds, widths, weights of vehicles and by restricting and regulating other elements likely to affect it unfavorably.

Signs giving the most important highway regulations are erected on all of the main roads entering Connecticut

Although the problem is comparatively new it has already received considerable attention. Many, if not all, of the States have enacted laws relating to traffic control in one form or another and several highway departments have developed a systematic practice for increasing the safety of their highways. Some States, as for instance Maryland, Connecticut, and Pennsylvania, have made systematic surveys of traffic conditions and have altered their practice in design according to the indications of such data. The American Association of State Highway Officials have a special committee now at work studying the whole subject, and the Bureau of Public Roads has gathered considerable data relating to safety devices, traffic control, and details of design calculated to increase safety on the highways.

BASIC PRINCIPLES OF HIGHWAY SAFETY

Recognizing these four considerations as the ends to be attained, the difficulties of the problem present themselves in matters of detail, expediency and practicability rather than in the establishment of fundamentals. The basic principles are easily defined and generally accepted. Reduced to the simplest terms they may be stated as follows:

1. The development of safe roads by elimination of all known dangers in so far as such elimination is possible within physical and economic limitations.

3781—24†—1

2. Warning of uneliminated dangers by means of easily recognized signs and other devices of standardized form, uniformly placed with respect to the danger.

3. The development of safe vehicles by perfection of running parts and adoption of safety devices.

4. Diligence and care in the licensing of drivers of motor vehicles to eliminate the incompetent, careless and irresponsible driver.

5. The development of simple, uniform, and effectual traffic regulations and the education of the whole public to a complete acquaintance with them.

Sign erected by Maryland State Roads Commission at top of a long, steep grade.

6. The rigid enforcement of traffic regulations.

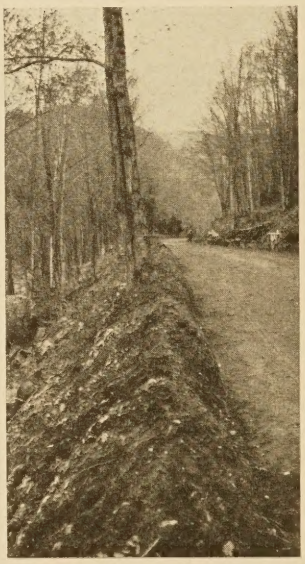
There is little doubt that a solution of the problem worked out on the basis of these general principles would have the effect of reducing the dangers of the open road to a minimum. It is the means of applying them practically and to the best advantage and especially the harmonizing of action by the 48 States that remains to be worked out. Already there have been applied in several of the States adequate solutions of some details of the problem, which if adopted generally would go far toward meeting the situation satisfactorily. One State has danger signs which are difficult to improve upon. Another has a scheme of road surface markings of decided merit. Our cities have developed by trial and experience excellent rules of the road. Some States and many cities require evidence of competence before licensing drivers. What needs to be done first, and what is already being done by the Committee on Traffic Control and Safety of the American Association of State Highway Officials which is working on the problem, is to review carefully the practices current in the several States. By so doing it should require but comparatively little effort and adjustment to secure the adoption of uniform measures by all States, which will take us far toward the desired solution of the highway safety problem.

INVESTIGATION OF CAUSES OF ACCIDENTS AN IMPORTANT PRELIMINARY STEP

As a preliminary step it is important that a careful study be made of the causes of accidents occurring on the highways. Studies of this sort have already been made in several States, and have proved invaluable as a guide to State officials by indicating the relative danger of various practices and conditions requiring correction. Such a record kept by C. H. Purcell, District Engineer, United States Bureau of Public Roads, in Oregon and Washington, rates the various causes of accidents occurring in those States during December, 1923, as follows:

	Oregon	Washington
Time:	*Per cent*	*Per cent*
Daylight	41.5	46.4
Darkness	53.6	44.9
Undetermined	4.9	8.7
Nature of accident:		
Collision between two motor cars	41.5	36.2
Collision between motor car and train	7.3	1.5
Motor car leaves road	36.6	43.5
Equestrian or pedestrian run down	12.2	13.0
Undetermined	2.4	5.8
Location:		
Grade crossing	7.3	2.9
Intersecting highways	12.2	7.2
On tangent	29.3	17.4
On curve	12.1	14.5
On grade	9.8	11.6
Undetermined	29.3	46.4
Visibility:		
Raining	2.4	
Snowing	2.4	2.9
Foggy	7.3	1.5
Clear	17.5	2.9
Undetermined	70.4	92.7
Causes:		
Faulty operation by driver—		
Incompetence and inexperience	7.3	2.9
Operation by intoxicated persons	7.3	4.3
Excessive speed	4.9	4.3
Recklessness and carelessness	51.3	59.4
Violation of traffic rules	7.3	14.5
Faults of other than drivers—		
Pedestrian fails to give right of way	[1]	1.5
Miscellaneous	[1]	5.8
Faulty equipment—		
Glaring headlights	[1]	5.8
Mechanical breakdowns	[1]	1.5
Faulty highway conditions	None.	None.

[1] Undetermined.



A roadside mound taking the place of a guard rail on a Massachusetts road

This record may not be in the best form to adapt it to comparison with other similar records which have been made in other States, notably in Maryland and Connecticut, but it appears to check those records in some interesting details. It would be an easy and simple matter to secure analyses of accidents in some uniform way wherever such analyses are attempted; and such records from widely separated sections of the country, by their agreement as to the relative hazards of the various causes of accidents, would point clearly to the corrective measures most urgently required and indicate the fields in which the work of standardization will be most effective in reducing dangers.

AVOIDANCE OF DANGEROUS ROAD CONDITIONS REQUIRES CONSTANT WATCHFULNESS

Much remains to be done in developing practice in design and construction of highways that will reduce the danger of traveling the open road. In this respect, as in others, the sources of danger are comparatively well known. What is needed is constant watchful-

ness to prevent the perpetuation of dangerous conditions, an aggressive policy of safety promotion, and public support for the expenditures required, which, in some cases are quite heavy.

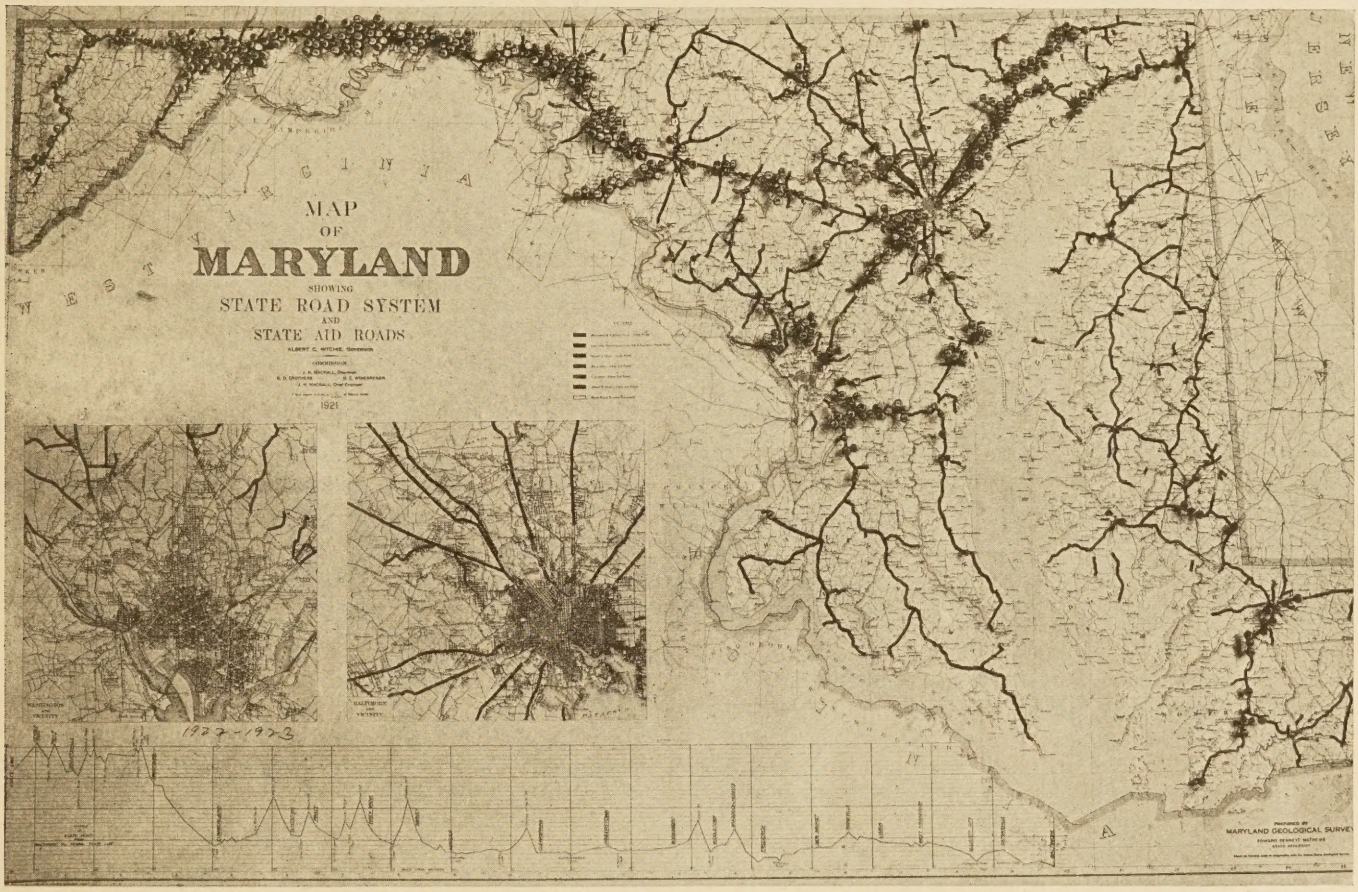
Few persons, asked to catalogue the principal dangers of the road, would fail to include those in the following list:

- Blind curves and road intersections
- Sharp curves on embankments
- Unprotected embankments
- Narrow bridges
- Sharp convex vertical curves
- Slippery road surfaces.
- Steep grades
- Narrow road surfaces
- Low or rough shoulders
- Steep crowns
- Sharp curves at bridge and underpass approaches
- Grade crossings
- Unsuperelevated curves

rapidly increasing traffic has forced the State to reconstruct a large number of curves on their earlier-built roads to make them safe. This practice has prevailed also for many years in Massachusetts.

18 FEET THE MINIMUM SAFE TWO-WAY WIDTH

Massachusetts formerly built a 14-foot macadam as its standard design. Maryland now frequently uses a 15-foot cross section even on new work. But in general, the opinion of engineers is crystallizing on 18 feet as the minimum safe two-way road surface, and in many cases a 20-foot standard section is being used on the principal routes. Safety against being forced to the shoulders depends first on ample width of surface and



Maryland's accident map has been useful in discovering the places on her State road system in need of betterment to relieve danger. Note the clustering of pins in mountainous western Maryland

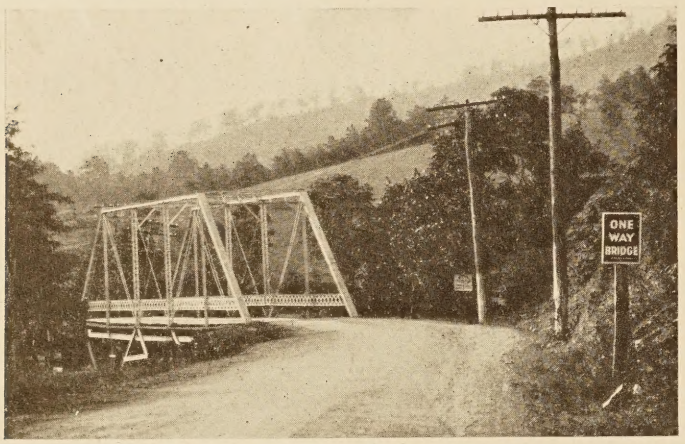
These, then, are some of the defects which should be avoided, so far as practicable, in future construction. A most important detail is that of providing adequate width for traffic and controlling the width of vehicles, because a hazard exists to passing drivers in having to leave the road surface on account of the inconsiderate or incautious driving of the other man. This danger is not confined to curves but is as great perhaps on tangents if we are to believe the evidence of the Maryland and Connecticut records. Against this, danger we can employ correctives in design and many States are doing so, especially on curves. The widening and superelevation of curves is now becoming very common and is standard practice on all new work in many States. There exists considerable variety in the assumptions and details of design, but the defects are essentially alike in all cases. In Maryland the on restriction of the width of vehicles. This latter must be a matter of traffic law and regulation, and the prevailing gauge of vehicles now used for generations indicates reasonable requirements to be enforced without great difficulty.

There always exists some danger of accident to passing vehicles because of loss of control by one or the other driver. Sometimes this is "psychological," due to nervousness or inexperience, inability to gauge correctly the clearance of the vehicle or the state of mind of the other fellow. This hazard is reduced by widening the road surface, and may always be further reduced by the control of speed and the reduction of gradients. "Speeding has no excuse" is a maxim that should be impressed on every driver. The world lived and progressed when limited to a speed of about 4 miles on the open road, and 18 or 24 miles give ample

multiple over the old way. Speeds in excess of 25 miles per hour are always likely to be dangerous because of the unforeseen.

On excessive gradients some States now warn the unsuspecting driver to attempt the down grade only in second gear. This indicates the element of competence and experience, of good judgment and care that must in the last analysis be depended upon in the critical case. The determination of the minus per cent of gradient requiring use of second gear in the average car, if it is to be a safe grade to travel, should be made, and a standard warning sign adopted.

In safe design we must emphasize, then, adequate original width of surface, control of width of vehicle, flattening and strengthening of shoulders, the use of guard-rail and other protective structures where high fills require them, the superelevation of curves and the lengthening of convex vertical curves, the securing of sufficient line of sight, the proper adjustment of profile and alignment to avoid dangerous combinations of gradient and curvature, and the proper type of surface.



Maryland's way of lessening danger at narrow bridges.

FEDERAL AID FOR ROADS A HARMONIZING FORCE

The Bureau of Public Roads has done much through its approval of designs for all Federal-aid roads to harmonize and develop good practice with respect to all the details mentioned. It has neither authority nor disposition to force matters, but it has waged an assiduous campaign of education and given the strongest possible support to all the State highway departments in securing all kinds of betterments in design. In States where the legal highway is along the section line, the flattening of curves has become common where it was unusual, grades are being reduced, guard rail included in designs, bridges widened and strengthened, and railroad grade crossings eliminated. In the enormously expensive and important item of grade crossing elimination alone there has been remarkable advance. No less than 25 per cent of all crossings so far encountered in the Federal-aid system have been eliminated by relocation or separation of grades in the premises. At present no standards of curvature or gradient are prescribed, because conditions are of such great variety throughout the country; but tentative policies have gradually hardened into more or less fixed practice that is generally followed. Some States, as for instance North Carolina, have adopted a maximum gradient of 6 per cent or lower, in line with the most advanced advocates of grade reduction. Other States, having a very irregular topography and advanced development, have not been so successful.

It is easily foreseen that there will be necessary in future years much betterment and replacement on highways already well located and improved. The banking and widening of curves, the reconstruction of low-capacity, narrow bridges, the flattening of shoulders and widening of fills, and the extension of the line of sight at curves will have to be done at considerable cost, because in the original design features were retained which are causes of accidents.

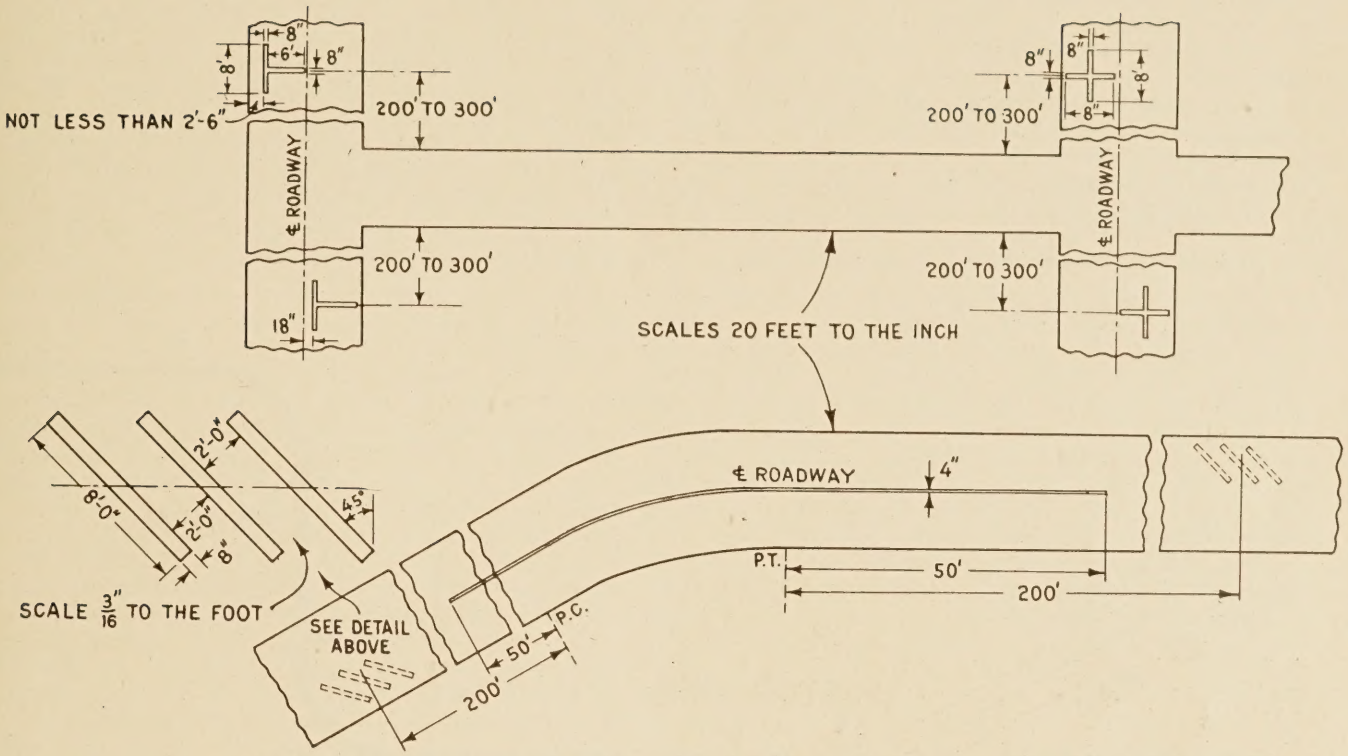
An excellent device which serves to draw attention to these danger spots in existing roads is an accident map such as that used by the Maryland State Roads Commission and others for several years. Adding a pin to such a map of the road system at the location of each accident as it occurs, and distinguishing between the causes of accidents by means of vari-colored pin heads serves to attract attention to the more dangerous places on the roads by the inevitable clustering of the pins. By carefully watching the map the Maryland Commission has been able to correct many dangerous conditions, and the beneficial results show up immediately in the subsequent map record.

In some instances the danger revealed by the map can only be dealt with by reconstruction or betterment of the road; in others the placing of a danger sign is the only practicable remedy at the time, and often does much to relieve the danger. Examples of such solutions in Maryland are shown in the illustration of the mountain grade warning sign on page 2 and the one-way bridge sign placed at the approach to a narrow bridge which, for the time being, it is impracticable to replace, as shown on this page.

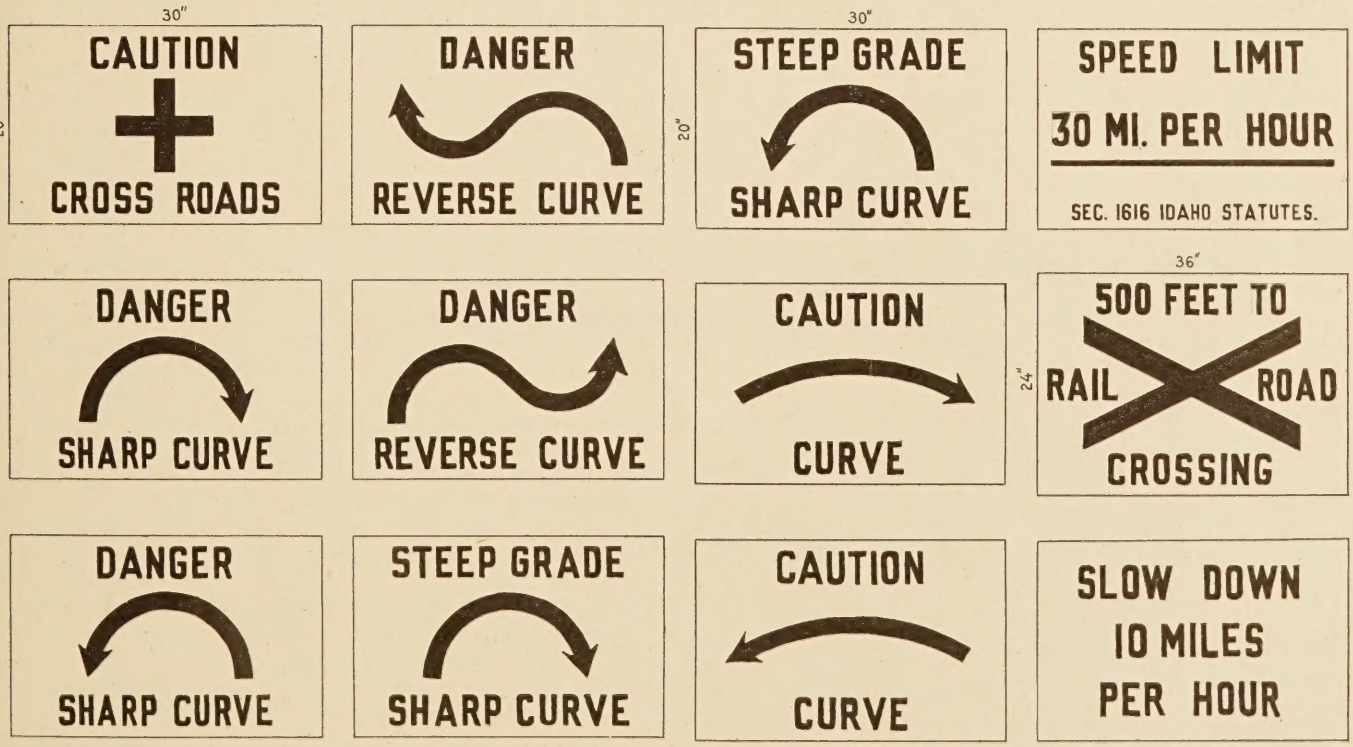
UNIFORMITY IN DANGER SIGNS LARGELY A PROBLEM OF SELECTION

It is, of course, impossible to build a highway which will be absolutely free of danger to its users. Curves and road intersections, grades, and embankments must remain in the best of roads, and each is potentially dangerous. All that can be done, then, is to give the traveler due warning of the danger. Signs, either diagrammatic or worded, are commonly used for this purpose, and in some States these have reached an entirely practical and useful stage of development. For instance, the series of danger signs adopted by the State of Idaho is especially effective. They are uniform in design, simple, bold, and striking. In contrast with these are those which rely too much on wording and require too much attention on the part of the passing driver. Washington, New Jersey, Ohio, and Tennessee have already adopted schemes essentially like that of Idaho and the possibilities of standardization are many, some of them obvious. Drivers in different States will recognize the signs as having identical meaning, the effect of repetition will educate, the use of the sign will become more general, the cost of manufacture will be reduced, the method of installing can be made more uniform than is now possible, and this in turn will expedite and cheapen the installation. The development of a complete series of danger signs and their general adoption and use is a problem in the safety of our highways.

Another method of reducing hazard at curves is by use of markings on the road surface to direct the path of traffic. The commonest mark is the "center line" in white or black. The latter, first adopted, is now generally giving away to white, which has much greater visibility under prevailing conditions. The system of traffic markings has been most completely developed probably in Massachusetts, but is also used generously



In Massachusetts signs painted on the surface of the roadway give warning of curves and intersecting highways



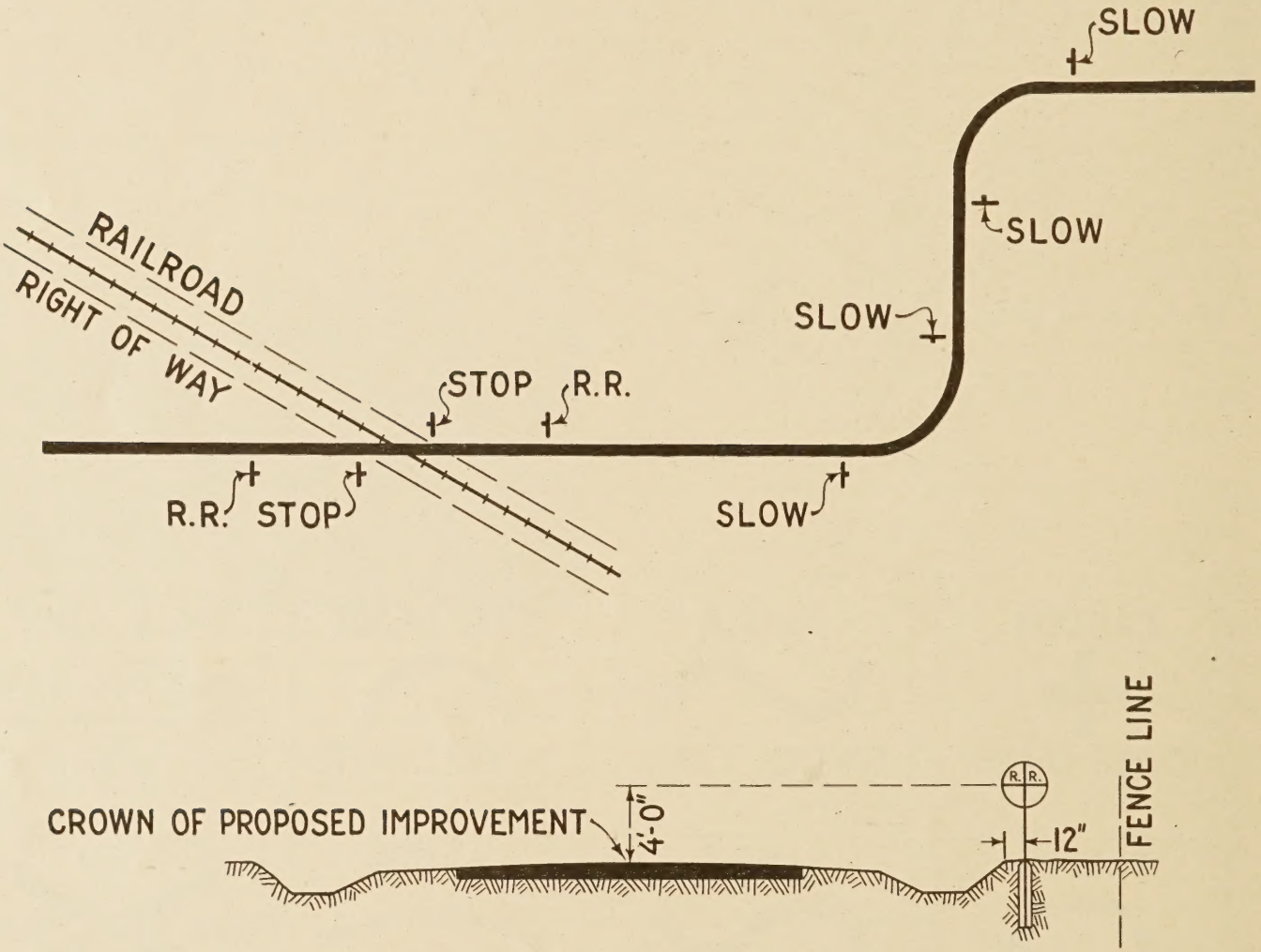
Standard danger signs adopted by the Idaho Department of Public Works

in Pennsylvania, Maryland, Delaware, New York, Illinois, and other States. This system is effectually confined to "black top" pavements, concrete, and other hard surfaces. In Pennsylvania experiments have been made in constructing a white center line integral with a concrete pavement. This is expected to save the cost of maintaining such markers and also to make it possible to extend their use widely—to tangents as well as to curves.

The diagrams on pages 5 and 6 of the location of signs and surface markers show the relative position of these with respect to curves and intersections. These are taken from Massachusetts and Kansas practice.

glance the nature of the hazard, he is prepared to meet it with due caution. Another element in promoting the safe use of the highways is indicated in the development and extension of these surface markings; and in this connection attention should be called to the great educational effect that is already produced by the common use of such markings on city streets. Drivers are learning to observe them.

Although accident records consistently indicate a relatively low percentage of wrecks due to faulty equipment, consideration should be given to certain details of motor-car design that are now largely responsible for the worst accidents and severest injuries occurring on



Plan for the placing of warning signs at grade crossings and dangerous curves used by the Kansas Highway Commission

CENTER LINES EFFECTIVE

The strongest effect produced by the center line at horizontal and vertical curves is its mental impression on the driver. Everyone knows that if a collision occurs, the blame rests on the one who is off-side. The center lines on blind vertical curves, and on curves in alignment of low visibility are powerful correctives of recklessness; they impress the observance of rules of the road, and obviously by so doing promote safety.

Surface markings are used to indicate highway intersections and railroad grade crossings as well as curves. The driver watching the road sees these as quickly and certainly, or perhaps more certainly than he does signs at eye level alongside of the road, and as the markings devised in Massachusetts, for instance, explain at a

account of defects in equipment. Probably the most conspicuous of the faulty details is the presence and use of glaring headlights and spot lights. This is a matter that is susceptible to correction by regulation, and it may be possible to apply the regulation at the source and actually prevent the manufacture and sale of those types of lamps that are most dangerous, as well as to prevent their use on vehicles.

WHAT OF FOUR-WHEEL BRAKES?

Next to glaring lights it is probable that defective brakes are the most frequent causes of collision attributable to equipment. This emphasizes a fact that is noted in connection with a large percentage of accidents involving mechanical devices. The very means of

safety to which we trust ourselves fail to act. The lesson is one for the car owner and no amount of regulation or inspection is practicable that would effect a remedy in this case. The man who undertakes to operate a power vehicle on the public highway at speeds approaching or exceeding those of many railroad trains, but without the safe guidance of a track, must depend to so large an extent on the effectiveness of his brakes that he should assume the responsibility of this detail at least. And if he fails to assume it and has a collision in consequence he should be held accountable beyond question. Faulty brakes should never be accepted as an excuse for anything.

The attempt of manufacturers to increase the security of braking devices by adding them to the front wheels may reduce the chances of accident by doubling the brakes available, or it may increase accidents by instilling a too great confidence in brakes. However, the introduction of the four-wheel brakes serves to indicate that the question of providing greater security of equipment is receiving consideration by those concerned in its manufacture.

The introduction of balloon tires also has its effect on the ease with which a car is steered and on the tractive effort exerted on the road surface. These tires doubtless do less damage to road surfaces than harder pneumatics or solid tires, but they may somewhat increase the stiffness of the steering mechanism.

The use of nonsplintering glass, automatic stop lights, reflecting mirrors, cowl and fender lights indicate some of the lesser details that aid in the reduction of accident or injury.

Other features of design, affecting more particularly the heavier and larger motor equipment, must be controlled in the interest of general safety. The width of truck body or of load must be kept down to a safe dimension and should not be greater than that customary for a standard guage vehicle with ordinary extensions such as wheel guards or fenders. A vehicle so wide that it converts a two-way road for a moment in passing into a one-way road so that traffic in the opposite direction is forced to the shoulder is never anything but a hazard, and what is more it represents license, not liberty, in the use of the public highway.

Consideration of the safety of the traffic will not produce a sufficient solution of traffic perils. There is the road itself to be considered. The relegation of a once substantial and serviceable method of road building to the discard of old practice was the direct result of two items—speed and tractive resistance. Road surfaces are still the victim of speed and to some extent of tractive resistance.

The control of weights is essential to the economic upkeep and reasonable life of the road itself and should be exercised through adequate regulations.

The idea exists still that the highway is an 18-foot track upon which any vehicle may be run that can be got upon the surface. Not so long ago the writer heard a high official of a prominent manufacturing company declare that the sound and economic procedure is to build the most economic truck or car possible, design it of such width, height, weight, and speed as is mechanically soundest and leave it to the highway administration to produce the modern highway required as a track for such an ideal vehicle. This way lies highway suicide. The public will pay the bill and no second mile of such highway would ever be built if a full discussion of the first mile were made public.

Safety of the road itself depends upon control of speed, of load per unit of bearing area, of width and height of body, of type of vehicle and of tire. The State of New Jersey has a traffic-control law considered as a model. It probably represents the maximum permissible requirements in most of its details and future developments will be toward lower requirements. Studies of actual traffic indicate this.

NO SOLUTION EFFECTIVE WITHOUT COMPETENT DRIVERS

The safety of the highways will not, however, be entirely secure until there is a standard of competence fixed as a prerequisite to driving. The wild driver is still at large on our highway and no details of design will save him from accidents. He may be a simple speed maniac or he may be a hopelessly erratic driver. He must be left to the tender mercies of the law, which should be executed not in consideration of him, but solely in consideration of the other fellow.

It was formerly believed that accidents prevailed at curves, either of grade or alignment, but there is considerable evidence from data compiled in Maryland that greater dangers of colliding exist, as cars are now driven, on the long, straight sections where the drivers "step on it" to the point of recklessness. However, such results are to be overcome only by the education of the man, not by alterations in design. The fact remains that curves and highway intersections are points of potential danger and become more than usually safe only because a driver is impressed with the exisiting hazard and avoids it.

It becomes at once important therefore that drivers be impressed with their responsibility to the general public to the point, first, of being allowed to drive only when proficient, and in the second place of driving strictly in accordance with the law, the rules of the road, and common courtesy. The pedestrian at least is interested to a certain degree in the last.

His rights are being infringed to a certain extent on all our highways, not so much by reason of his being excluded from the road, but because he can not use the road without exposing himself to hazards more or less serious. The rule of the sea in respect to sailing ships is an old and tried one, safe, and sane, and reasonable. The steamer shifts her course to protect the sailing vessel. The vehicle of greater power and speed yields to the weaker and slower. So the automobile should yield to the pedestrian when their paths intersect. To avoid annoying and frequent intersections they both should observe common-sense rules, and the pedestrian should do this no less than the driver. Our highway designs should include a shoulder amply wide to be used as a pathway, and so constructed as to be a serviceable path, firm, hard, and even. Pedestrians should walk on the left-hand side of the road and carry a lantern at night. These are details that must generally be developed by educational means. Regulation will do something to secure results, but fundamentally it is resolved into a matter of personal care and custom of the pedestrian.

EXAMINATIONS AND INSURANCE AS PROTECTION AGAINST IRRESPONSIBLE DRIVERS

Some form of examination of prospective drivers is required in a number of States. In some it is little more than a form. Certainly it should be searching in character, and carefully given. Many States require a permit to drive, but set no standard of proficiency and give no examination. Generally a minimum age below which a permit may not be received is fixed by the law. Certain advances can well be made in efforts to raise the standard of driving.

Every man on his own side. The Pan American Highway Commission on tour in North Carolina honors the white line

The examination system should be extended. The question of compulsory insurance has been advanced in at least one State, and if properly controlled is no doubt sound. It at least will protect the victim of accident from loss or damage caused by the reckless and irresponsible driver. It may also stiffen the examination system by coupling with it certain policy requirements of the insurance companies as to proficiency of drivers.

Certain penalties have also been considered that attempt "to make the punishment fit the crime" of violating the ethics of good driving. One is to deny to the driver the privilege of driving by revoking his license. In some cities and States this is now possible under the law. The law is not enforced as often as it should be, possibly because it is a punishment so entirely fitting that it seems to be too severe.

The safety of a single vehicle can be secured with comparative ease, economy, and some slight display of common sense by the driver. The matter is largely in his own hands. When the safety of passing vehicles is in question, however, there enter a number of new and important details, sometimes difficult of adequate solution. The much overworked word "pyschology" may be invoked because the simultaneous use of the highway by many drivers requires that each one shall have at least some assurance, some more or less definite idea of what each of the other is going to do in any ordinary situation arising. The simplest illustration of the requirement is the knowledge each driver has that one meeting him will turn to the right and pass on his left side. One of the important features of safety involves the extension of these simple practices to as many general conditions as possible.

To accomplish this result the education of the driver is necessary, and his observance of the instruction must be secured. Several States have devised simple schemes for impressing those in charge of motor vehicles with the elements of safe driving. Much has been written, there are certain "rules of the road," and safety will, in general, be promoted in proportion as these become developed, understood, and observed.

PRINCIPLES OF TRAFFIC REGULATIONS

Generally these are incorporated into ordinances called traffic regulations, and a great deal of study has been given to the proper methods of dealing with the peculiar problems involved. Traffic regulations should be devised to expedite the safe movement of traffic. As such they should cover in general the course of the vehicle on the road, its position when at rest, its speed, condition, control, and method of operation as affecting other vehicles. The rules should be simple and susceptible of rigid enforcement.

Obviously the advantage in traffic regulations is greatly increased by uniformity. The excellence of a regulation is increased by its uniform application elsewhere, because traffic is no longer only local in origin. The foreign car, so called, is common on most of our roads. They will become more so as road improvement is extended, and the use of identical regulations everywhere, on the rural road as well as in the city street, will make the highway safer. To this end the wider use of the same traffic and driving signals and the same signs as are now commonly used in cities should be effected so far as practicable.

Where marked differences now exist it is a good idea to see that the motorist coming from another State is informed of the salient features of the law and regulations by the use of a large, conspicuous sign at the State line, in which is set out clearly and briefly the important points of interest to the driver. Such signs are used by some States and a typical case is shown in the Connecticut sign on page 1.

Pennsylvania's cable guard rail is an effective safeguard

LAW ENFORCEMENT DIFFICULT BUT IMPERATIVE

It is clear that much can be accomplished by regulation and the driving habits formed by the enforcement of the rules in cities. The success of the regulation lies to a great extent in the way the law is enforced. In general, it is the common opinion that there is too much laxity. Recently there have been made again a number of suggestions, not new, but revised, for severe penalties. They are made almost annually or whenever a new sheaf of statistics of highway accidents is published. The principal suggestions are jail sentences

instead of fines, revocation of licenses, and impounding of the vehicle for a limited period. The National Automobile Chamber of Commerce has recently advocated impounding the car of the reckless driver.

The matter of strict enforcement of traffic laws is as difficult as it is imperative. The need of additional traffic police in cities has been apparent as traffic has increased until to-day the traffic squad is a large element in the personnel of the police department. To police the open highway in the same way is impracticable and unnecessary; but some form of more or less ubiquitous policing is essential and the creation of county and State police organizations seems to present a solution. Some States have already developed extremely efficient rural police corps. Massachusetts presents a conspicuous example of such a body of trained men. Maine, New York, Pennsylvania, and Maryland have rural or highway police and some States have county police. These men are provided with motor transportation and the rapidity with which they can patrol the roads, and the fact that they may appear anywhere at any time, gives them an efficiency and influence which is large in proportion to their number.

The law of North Carolina requires all vehicles to come to a complete stop at railroad crossings. The law is difficult to enforce and of questionable value

DIRECTION SIGNS AS AN ELEMENT IN SAFETY

A first aspect of the whole matter, and one that is possible of ready solution, is the protection of the traveling public against loss of direction and location. In cities this is effected by the common use of street names and signs. It should be systematized and extended to the entire highway system in such a way as to create a corresponding degree of certainty against the hazard of losing one's way. The long distance traveler is becoming more and more common and strangers to a locality should be able to count upon an intelligent system of directional signs, route markers, and other devices for indicating the direct and customary routes of the improved system of roads. This detail in the scheme of making the highways serviceable as well as safe has been highly developed in some States. Wisconsin has so carefully and fully marked the State road system that it has used the slogan, "It is harder to lose your way on Wisconsin highways than it is to find your way in some States." It should be made difficult to lose one's way anywhere on the entire national system of roads. To this end many States have already adopted distinctive markers which are now well known in many instances. In general these markers are most successful where they approximate the type used in Minnesota, whose star carrying the State route number is so generously scattered over the State. The keystone of Pennsylvania, the State outlines of South Dakota, Iowa, and Illinois, and the Indian head of North Dakota are samples of successful markers. Each of these is so designed that the sign is approximately 15 by 15 inches and each bears conspicuously the State route number. In all cases the design selected should be simple and should carry conspicuously the particular designation, usually a number.

The Michigan route marker

In this connection it may be noted that a system of numbering, properly devised and developed, offers one of the simplest and easiest schemes to apply to the designation of the large mileage and more or less complicated layout of a State-wide or nation-wide system of roads. So far only slight effort has been made to correlate the numbering in adjacent States and a large field for careful adjustment here presents itself. Minnesota and Iowa have continuously numbered routes and a few other States have aimed at a similar arrangement, but no concerted attempt has yet been made by all States.

UNIFORM NUMBERING SYSTEM UNDER CONSIDERATION

Such a plan is now being studied, however, by the Bureau of Public Roads and the Committee on Traffic Control and Safety of the American Association of State Highway Officials and it is hoped that a practicable arrangement will be worked out for presentation to the association at its next annual meeting in November. The plan under consideration is to adopt as numbers for the Federal-aid highway system, which is correlated

Whitewashed telephone poles, trees, and culvert headwalls to mark the road for night driving in Maryland

and connected throughout the entire country, all one and two digit numbers. This will give 50 odd and 49 even numbers and provide for 99 through routes. The odd numbers would be given to connecting and con-

(Continued on page 19)

PRACTICAL FIELD TESTS FOR SUBGRADE SOILS

SUGGESTED METHODS FOR MEASURING THE CHARACTER OF HIGHWAY SUBGRADES

By A. C. ROSE, Associate Highway Engineer, U. S. Bureau of Public Roads

THE character and condition of the subgrade, the kind and volume of the traffic, and the climatic conditions seem to be the three major factors which limit the life or usefulness of a road surface. The climatic conditions can be exactly determined from the records of the United States Weather Bureau. It is believed that an investigation of the trend and possibilities of economic development of a region together with traffic surveys should give a reasonably close estimate of the kind and volume of traffic. This article suggests a means of evaluating the third variable in the problem by outlining a method for measuring the character and condition of the subgrade.

It seems evident that it should be possible to prescribe the kind and dimensions of a road surface when the three factors outlined above have been evaluated for any given case and after existing satisfactory road surfaces (preferably local) have been observed. Although the increasing traffic is rapidly forcing a change in the design of road surfaces, it is believed that a survey of existing surfaces would mark a step forward in highway transport.

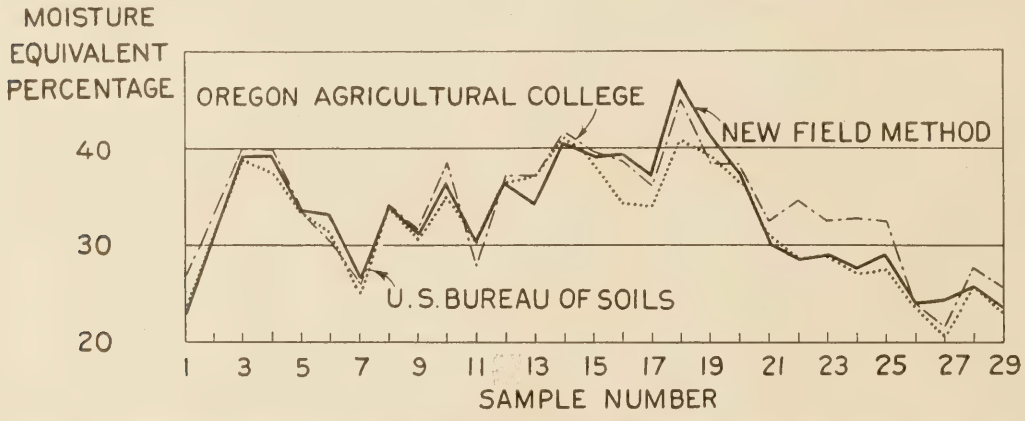


FIG. 1.—Comparison of field test for moisture equivalent with standard laboratory tests by the United States Bureau of Soils and Oregon Agricultural College

The methods herein outlined were evolved during a field study of road surfaces in the Pacific Northwest with a view to finding out the cause of certain road failures and developing methods of construction which would avoid a recurrence of similar conditions. The findings have been used to determine the character and dimensions of the surfacing on proposed road projects submitted for construction with Federal aid.

THE VARIABLE CHARACTER OF ROAD SUBGRADES

The character of road subgrades varies from solid rock through compacted gravel, hardpan, loose rock, gravel, sand, clay, colloidal clay, and swamp land to quicksand. Generally speaking, the bearing power of dry soils increases with the size of the particles. In the following table one recognizes immediately that the coarsest materials are those which possess the greatest supporting power.

	Diameter in millimeters
Fine gravel	2 to 1.
Coarse sand	1 to 0.5.
Medium sand	0.5 to 0.25.
Fine sand	0.25 to 0.10.
Very fine sand	0.10 to 0.05.
Silt	0.05 to 0.005.
Clay	less than 0.005.

Closely related to the size and character of the particles composing the soil is its ability to hold water against the force of gravity, i. e., its capillary or water-holding capacity, and this relationship is so definite, and the determination of the moisture-holding properties is so much simpler than mechanical analysis that it is preferred to the latter by the majority of investigators as a means of classifying soils.

The practical laboratory test is to determine the percentage of water the soil will hold in opposition to a force equal to 1,000 times the force of gravity, as developed in a centrifuge, and the percentage determined in this manner is known as the *moisture equivalent* of the soil.[1]

It has been found by experiment that the moisture equivalent percentage varies with the size and character of the soil grains. The smaller the grains, the greater is their surface area in a given volume of the soil and the larger is the moisture equivalent percentage. The character of the grain, whether glazed or rough, porous or solid, etc., also affects the test.

R. L. Pendleton states in regard to the moisture equivalent percentage that "This determination showed quite distinct averages for the types. Eliminating those samples shown to be nontypical according to the mechanical analysis, the variation within the type is reduced considerably. Yet it can not be said as regards this constant that all soils mapped under a given type name or even those soils under a given type name which the mechanical analysis has shown to be true to name have closely similar moisture equivalents. Briggs and McLane express the belief that ultimately moisture equivalent determinations will replace mechanical analysis in the classification of soils, because the determination is simple and the result can be expressed as a single constant."[2]

FIELD TEST FOR MOISTURE EQUIVALENT OF SOILS

Since the degree of fineness of the grains of a soil seems to determine its quality for road foundations, and since the moisture equivalent percentage has been found to bear a close relation to the degree of fineness it is desirable to develop some means of approximately determining the latter characteristic, without employing the centrifuge, the use of which is not practicable in the field. With this in mind the following field test has been devised:

The test is made by taking a 500-gram sample of air-dried soil, breaking up the lumps, placing the sample in a bowl, adding water slowly from a burette, mixing the water and soil until it reaches the consistency of

[1] For description of the standard laboratory test for moisture equivalent, see Public Roads, Vol. 4, No. 3, July, 1921, p. 16.

[2] Are soils mapped under a given type name by the Bureau of Soils method closely similar to one another? University of California Publications in Agricultural Science, Vol. 3, No. 12. Page 469.

putty and may be compacted with a spoon or spatula without any free water remaining on the surface. Water is then allowed to drop upon the smoothed surface as long as it is absorbed. Before the moisture equivalent percentage is reached the sample will absorb water readily but when the critical value is passed the surface will retain a wet, shiny appearance. The sample is then dried out at 105° C. and the percentage of water is calculated on the basis of the dry weight of the soil. This procedure eliminates the time and labor required to oven-dry and pulverize a sample. Pieces of rock larger than one-eight inch are removed.

TABLE 1.—*Results of moisture equivalent tests made by the United States Bureau of Soils*

Sample No.	Mechanical analysis—Per cent between Millimeters							Moisture equivalent percentage, standard method (centrifuge)
	2–1	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05	0.05–0.005	0.005–0	
	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay	
1	0.0	0.0	0.4	1.5	12.3	64.9	20.9	23.8
2	0.0	0.6	1.0	6.4	21.2	46.5	24.4	30.7
3	0.0	1.8	3.0	11.6	16.4	39.3	28.1	38.9
4	0.0	1.3	1.5	7.7	8.5	39.6	41.4	37.5
5	0.0	2.9	2.7	9.0	12.9	41.0	31.3	33.8
6	0.2	0.5	0.5	4.5	10.9	49.3	34.0	31.3
7	0.0	0.3	0.4	4.1	10.9	59.6	24.6	25.2
8	0.0	1.0	0.8	5.4	14.8	46.0	31.9	33.9
19	0.0	0.3	0.5	4.3	10.7	47.2	37.0	30.5
10	0.0	0.9	1.2	8.0	8.2	39.1	42.6	34.9
11	0.0	0.0	1.1	3.3	13.0	48.3	34.3	30.5
12	0.0	1.6	1.7	8.2	9.4	40.7	38.3	36.4
13	0.0	1.8	1.8	10.7	11.3	35.2	39.3	37.5
14	0.0	2.5	2.2	8.5	6.7	34.6	45.4	41.2
15	0.0	7.2	5.8	19.4	12.7	28.2	26.7	38.5
16	0.0	1.5	1.6	8.4	10.5	36.7	41.3	34.4
17	0.0	0.6	0.9	6.1	10.0	46.3	36.2	34.1
18	0.0	1.3	1.8	8.7	10.6	37.6	40.0	40.8
29	0.0	3.9	3.2	26.3	28.8	25.8	11.9	39.1
20	0.0	0.4	0.6	6.5	22.8	39.7	30.0	36.3
21	0.0	0.7	0.9	10.7	24.9	35.7	27.1	30.9
22	0.0	0.6	0.5	3.0	17.8	53.4	24.6	28.3
23	0.0	0.4	0.3	2.7	22.8	47.6	26.2	28.7
24	0.0	0.4	0.5	3.0	21.3	47.2	27.6	27.2
25	0.0	0.4	0.3	3.0	12.0	60.3	24.1	27.5
26	0.3	0.3	0.5	2.9	22.3	61.1	12.2	23.2
27	0.1	0.5	0.8	4.8	22.6	61.4	9.2	20.4
28	0.0	0.2	0.3	2.0	23.5	50.9	23.0	25.7
29	0.0	1.4	2.0	4.9	19.3	56.8	15.6	23.0

TABLE 2.—*Moisture equivalent results by Oregon Agricultural College and field method*

Sample No.	Oregon Agricultural College		Difference A–B	United States Bureau of Public Roads, District 1		Difference C–D
	1st run A	2d run B		1st run C	2d run D	
1	26.95	27.02	0.07	22.5	22.9	0.4
2	34.03	33.98	0.05	31.1	30.2	0.9
3	40.12	39.98	0.14	38.5	40.0	1.5
4	40.50	39.34	1.16	39.1	39.5	0.4
5	34.16	34.01	0.15	33.7	33.7	0.0
6	30.68	30.47	0.21	33.3	32.6	0.7
7	25.87	26.01	0.14	26.2	26.8	0.6
8	34.16	33.94	0.22	34.2	34.0	0.2
9	31.45	31.58	0.13	31.8	30.7	1.1
10	38.01	38.64	0.63	35.9	37.0	1.1
11	28.12	27.94	0.18	30.1	30.4	0.3
12	37.44	37.03	0.41	36.6	36.2	0.4
13	37.49	37.42	0.07	34.2	34.2	0.0
14	41.54	42.09	0.55	39.8	41.4	1.6
15	39.78	39.42	0.36	38.8	39.6	0.8
16	38.58	38.90	0.32	39.4	39.2	0.2
17	36.19	36.23	0.04	37.2	37.2	0.0
18	45.09	45.27	0.18	47.3	46.8	0.5
19	38.45	38.79	0.34	41.7	41.7	0.0
20	38.73	38.21	0.52	37.3	37.2	0.1
21	32.49	32.51	0.02	30.2	30.0	0.2
22	34.31	34.89	0.58	28.2	28.6	0.4
23	32.73	32.22	0.51	28.2	29.3	1.1
24	32.96	32.48	0.48	27.4	27.7	0.3
25	32.32	32.53	0.21	27.2	30.6	3.4
26	23.54	23.50	0.04	23.2	24.5	1.3
27	21.13	21.68	0.55	24.1	24.4	0.3
28	27.95	27.34	0.61	26.3	24.8	1.5
29	25.31	25.42	0.11	23.4	23.6	0.2
Total differences			8.98			19.5

In order to determine how closely a refinement of this field method would agree with the results obtained by the standard laboratory test, 29 soil types varying from silt to clay were sampled and divided into three portions. One set of samples was oven-dried at 105° C. and pulverized to pass a 1-millimeter (1/25-inch) screen and then tested by the field method. The other samples were tested by the standard laboratory method by the United States Bureau of Soils and the Oregon Agricultural College, and the results of the three tests for the corresponding samples are shown in Figure 1. The appearance of a soil before, during, and after the field moisture equivalent test has been made is shown in Figures 2, 3, and 4.

FIG. 2.—Oven-dried soil pulverized to pass a 1-millimeter ($\frac{2}{5}$-inch) screen

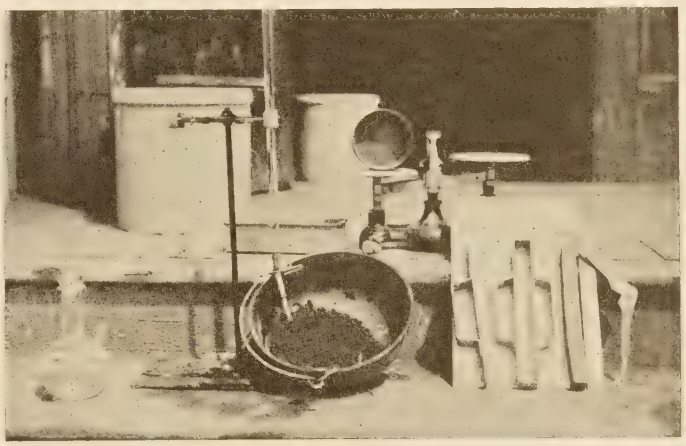


FIG. 3.—Same soil wetted to approximately one-half the moisture equivalent percentage

FIG. 4.—Same soil wetted to the moisture equivalent percentage

The mechanical analysis and the moisture equivalent results of the United States Bureau of Soils are given in Table 1. The difference between the original and check tests by the Oregon Agricultural College and the field method are shown in Table 2. The sum of the differences is decidedly in favor of the laboratory method although the results seem to indicate that the field method is close enough for all practical purposes.

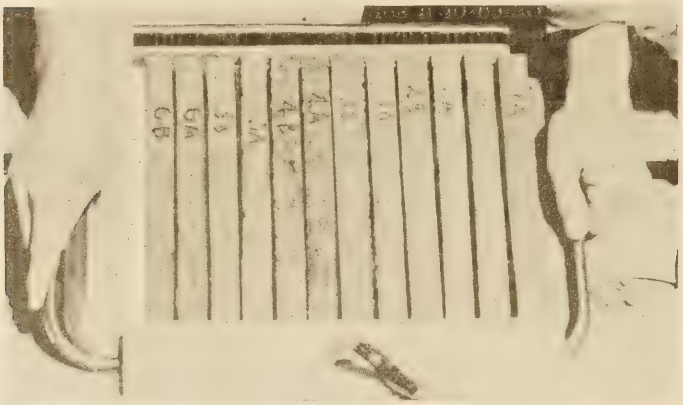


FIG. 5.—Soil bars, wetted to the moisture equivalent percentage, before drying

The moisture equivalent results by the three agencies and the residuals are given in Table 3. Considering the results of the Bureau of Soils as correct, the probable errors, by the method of least squares, for the Oregon Agricultural College and the field method are ± 1.9 and ± 1.4 respectively.

FIG. 6.—Same soil bars after being oven-dried at 105° C.

FIELD METHOD FOR DETERMINING THE LINEAL SHRINKAGE PERCENTAGE OF SOILS

It is desirable, also, to determine the lineal shrinkage percentage of various soil types because the vertical displacement or distortion of the subgrade, resulting from the shrinkage or swelling of the soil, is a factor which limits the life of a road surface, and what appears to be a practical field method of making this test has also been developed. It is described as follows:

Procedure.—A 300-gram sample of soil wetted to the moisture equivalent percentage is packed in ½-inch layers in a galvanized iron mold with a wooden tamper (½ inch by 1½ inches by 14 inches). The bars after being weighed are pushed from the mold upon a porcelain plate and calipered and then oven-dried at 105° C. and calipered again. (See figs. 4, 5, and 6.) The difference in length computed as a percentage of the wet length of the bar is considered the lineal shrinkage percentage. The volumetric shrinkage percentage is computed on the assumption that the shrinkage is uniform in all three dimensions. A computed graph showing the relation between the lineal and volumetric shrinkage factor is given in Figure 7.

Original and check runs made to determine the lineal shrinkage percentage of the 29 soil samples previously described are shown in Table 4, from which it will be

TABLE 3.—*Moisture equivalent percentages as determined by the three agencies*

Sample No.	Moisture equivalent percentages			Differences		Residuals	
	United States Bureau of Soils (A)	Oregon Agricultural College (B)	United States Bureau Public Roads District 1 (C)	A–B	A–C	$(A-B)^2$	$(A-C)^2$
1	23.8	27.0	22.7	−3.2	+1.1	10.24	1.21
2	30.7	34.0	30.6	−3.3	+0.1	10.89	0.01
3	38.9	40.0	39.2	−1.1	−0.3	1.21	0.09
4	37.5	39.9	39.3	−2.4	−1.8	5.76	3.24
5	33.8	34.1	33.7	−0.3	+0.1	0.09	0.01
6	31.3	30.6	33.0	+0.7	−1.7	0.49	2.89
7	25.2	25.9	26.5	−0.7	−1.3	0.49	1.69
8	33.9	34.0	34.1	−0.1	−0.2	0.01	0.04
9	30.5	31.5	31.2	−1.0	−0.7	1.00	0.49
10	34.9	38.3	36.4	−3.4	−1.5	11.56	2.25
11	30.5	28.0	30.2	+2.5	+0.3	6.25	0.09
12	36.4	37.2	36.4	−0.8	0.0	0.64	0.0
13	37.5	37.4	34.2	+0.1	+3.3	0.01	10.89
14	41.2	41.8	40.6	−0.6	+0.6	0.36	0.36
15	38.5	39.6	39.2	−1.1	−0.7	1.21	0.49
16	34.4	38.7	39.3	−4.3	−4.9	18.49	24.01
17	34.1	36.2	37.2	−2.1	−3.1	4.41	9.61
18	40.8	45.2	47.0	−4.4	−6.2	19.36	38.44
19	39.1	38.6	41.7	+0.5	−2.6	0.25	6.76
20	36.3	38.5	37.2	−2.2	−0.9	4.84	0.81
21	30.9	32.5	30.1	−1.6	+0.8	2.56	0.64
22	28.3	34.6	28.4	−6.3	−0.1	39.69	0.01
23	28.7	32.5	28.8	−3.8	−0.1	14.44	0.01
24	27.2	32.7	27.6	−5.5	−0.4	30.25	0.16
25	27.5	32.4	28.8	−4.9	−1.3	24.01	1.69
26	23.2	23.5	23.8	−0.3	−0.6	0.09	0.36
27	20.4	21.4	24.2	−1.0	−3.8	1.00	14.44
28	25.7	27.6	25.6	−1.9	+0.1	3.61	0.01
29	23.0	25.4	23.5	−2.4	−0.5	5.76	0.25
Totals						218.97	120.95

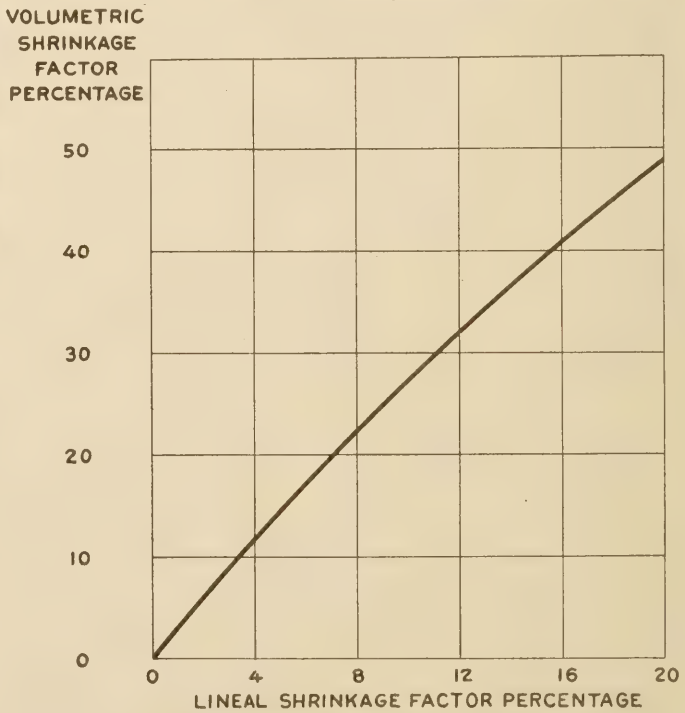


FIG. 7.—Relation between lineal and volumetric shrinkage

noted that the two determinations check very closely, and the relation of lineal shrinkage to the moisture equivalent of the same samples is represented by Figure 8.

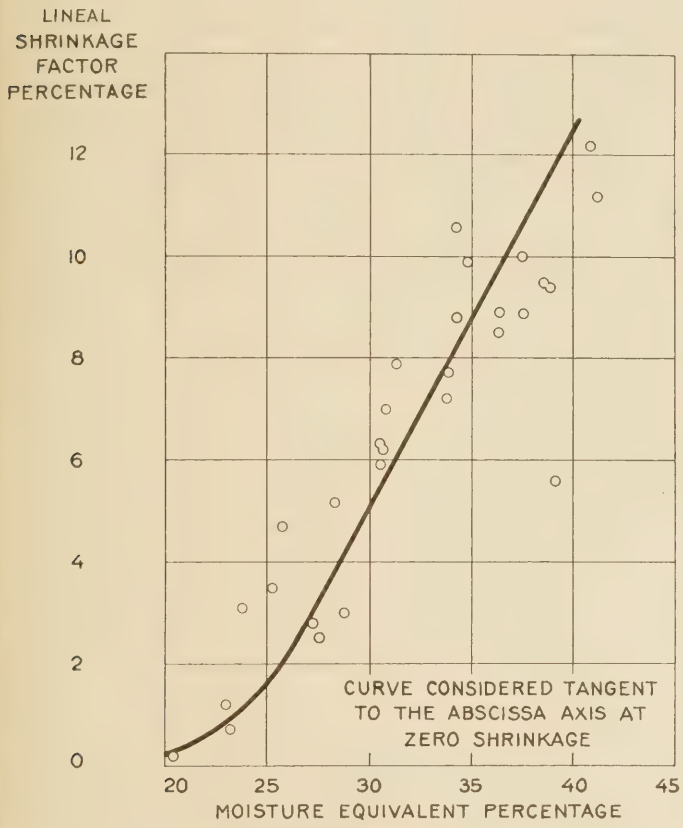


FIG. 8.—Relation of lineal shrinkage to moisture equivalent for 29 soil samples from Oregon Federal-aid project No. 51

TABLE 4.—*Field determinations of lineal shrinkage of soils*

Sample No.	Length of compacted bar in inches				Shrinkage of bar						Moisture equivalent
	Wet		Dry		1st run	2d run	1st run	2d run	Average observed lineal shrinkage	Volumetric shrinkage (computed)	
	1st run	2d run	1st run	2d run							
					Inches	*Inches*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	10 8/64	10 2/64	9 52/64	9 47/64	20/64	19/64	3.1	3.0	3.05	8.8	22.7
2	10 4/64	10 3/64	9 27/64	9 29/64	41/64	38/64	6.4	5.9	6.15	17.25	30.65
3	10 2/64	10 2/64	9 6/64	9 3/64	60/64	63/64	9.3	9.8	9.55	26.2	39.25
4	10 2/64	10 1/64	9 2/64	9 1/64	64/64	64/64	10.0	10.0	10.0	27.1	39.30
5	10 4/64	10 0/64	9 2/64	9 19/64	66/64	45/64	10.2	7.0	8.6	23.6	33.70
6	10 2/64	10 4/64	9 15/64	9 17/64	51/64	51/64	7.9	7.9	7.9	21.75	32.95
7	10 2/64	10 0/64	9 44/64	9 41/64	22/64	23/64	3.4	3.6	3.5	10.2	26.50
8	10 2/64	10 2/64	9 16/64	9 17/64	50/64	49/64	7.8	7.6	7.7	21.5	34.10
9	9 63/64	10 2/64	9 21/64	9 27/64	42/64	39/64	6.6	6.1	6.35	17.8	31.25
10	10 2/64	10 1/64	9 4/64	9 1/64	62/64	64/64	9.7	10.0	9.85	26.5	36.45
11	10 1/64	10 0/64	9 26/64	9 28/64	39/64	36/64	6.1	5.6	5.85	16.5	30.25
12	10 1/64	10 2/64	9 9/64	9 8/64	56/64	58/64	8.7	9.0	8.85	24.25	36.40
13	10 2/64	10 1/64	9 8/64	9 9/64	58/64	56/64	9.0	8.7	8.85	24.2	34.20
14	10 1/64	10 2/64	8 57/64	8 58/64	72/64	72/64	11.2	11.2	11.2	30.0	40.60
15	10 2/64	10 2/64	9 5/64	9 5/64	61/64	61/64	9.5	9.5	9.5	25.9	39.20
16	10 2/64	10 2/64	8 63/64	8 61/64	67/64	69/64	10.4	10.7	10.55	28.3	39.30
17	10 2/64	10 3/64	9 9/64	9 11/64	57/64	56/64	8.9	8.7	8.8	24.25	37.20
18	10 3/64	10 2/64	8 52/64	8 52/64	79/64	78/64	12.3	12.1	12.2	32.2	47.05
19	10 2/64	10 3/64	9 31/64	9 31/64	35/64	36/64	5.5	5.6	5.55	15.8	41.7
20	10 2/64	10 1/64	9 11/64	9 11/64	55/64	54/64	8.6	8.4	8.5	23.5	37.25
21	10 2/64	10 0/64	9 21/64	9 19/64	45/64	45/64	7.0	7.0	7.0	19.6	30.10
22	10 2/64	10 0/64	9 31/64	9 30/64	35/64	34/64	5.5	5.3	5.4	15.3	28.40
23	10 0/64	9 63/64	9 45/64	9 44/64	19/64	19/64	3.0	3.0	3.0	8.6	28.75
24	10 0/64	9 63/64	9 46/64	9 45/64	18/64	18/64	2.8	2.8	2.8	8.3	27.55
25	9 62/64	9 62/64	9 47/64	9 46/64	15/64	16/64	2.3	2.5	2.4	7.0	27.90
26	9 60/64	9 62/64	9 57/64	9 57/64	3/64	5/64	0.5	0.8	0.65	2.0	23.85
27	9 62/64	9 58/64	9 62/64	9 56/64	0/64	2/64	0	0.3	0.15	0.4	24.25
28	10 1/64	10 2/64	9 33/64	9 38/64	32/64	28/64	5.0	4.4	4.7	14.0	25.55
29	9 58/64	9 63/64	9 52/64	9 54/64	6/64	9/64	0.9	1.4	1.15	3.4	23.50

A ROUGH PRACTICAL METHOD OF CLASSIFYING SUBGRADE SOILS

Using these field tests a series of studies of road subgrades have been made in the States of Oregon and Washington which are included in Bureau of Public Roads District No. 1, as one of the results of which a method of roughly classifying subgrade soils by means of a soil classification triangle, shown in Figure 9, has been evolved. This triangle is plotted according to Professor Ferèt's method (Annales Des Ponts et Chaussées, 1892). Its use is based on the fact that in any equilateral triangle, the sum of the perpendiculars from any point to the three sides is equal to the altitude of the triangle. Thus at intersection A, the soil contains 37.6 per cent silt, 6.7 per cent sand, and 55.7 per cent clay, and is classified CLAY. The soil nomenclatures shown by the shaded areas are believed to be representative of the practice of the leading authorities. The percentages represent the results obtained by a mechanical analysis. The horizontal lines represent the percentages of clay which, it is believed generally, determine the quality of the soil for a road subgrade. Thus it is believed that, as a rule, a soil containing less than 20 per cent of clay makes a good subgrade, one containing from 20 to 30

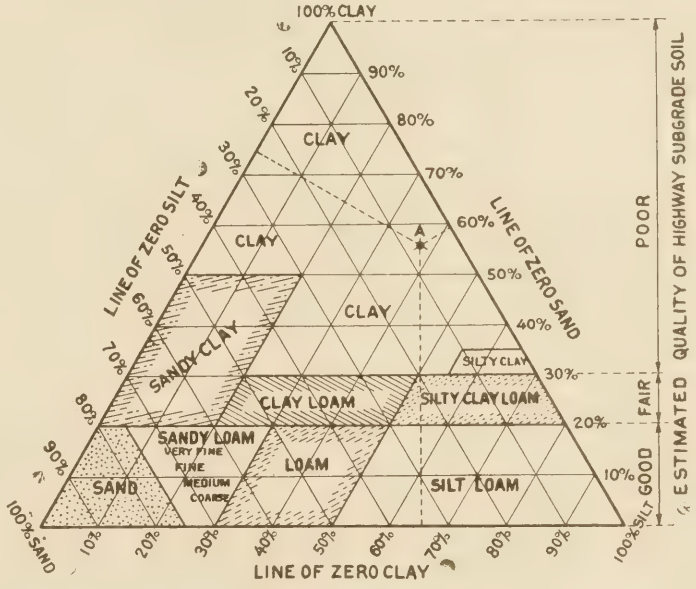


FIG. 9.—Trilinear soil classification chart

per cent of clay a fair subgrade, and one containing more than 30 per cent a poor subgrade.

The field observations of the bureau indicate that, for road soil reconnaissance survey purposes, the clay content by mechanical analysis may be considered as equal to the moisture equivalent percentage. Adopting this assumption (see Table 1) the basis of the above classification is apparent in Figure 8. As shown by this figure the field observations indicate that when the moisture equivalent is less than 20, the lineal shrinkage is too small to be measured and the soil makes a good subgrade; when the moisture equivalent percentage varies from 20 to 30 the average maximum lineal shrinkage is about 5 per cent and the soil makes a fair subgrade; but when the moisture equivalent exceeds 30 per cent, the average maximum lineal shrinkage becomes excessive and the soil makes a poor subgrade. Therefore, in regions where soil survey

bulletins are available, this chart may be used in making a reconnaissance survey of the subgrade soil on a road project. But these results should be verified in all cases by actual tests, at least until the soil types of the region have been evaluated.

OTHER FINDINGS OF THE SUBGRADE STUDIES

Other major findings of the bureau's subgrade studies follow:

1. The field moisture equivalent test seems to give results practically identical with the standard laboratory methods.

2. A moisture equivalent percentage of 20 seems to be critical in respect to the bearing power of a soil. When the moisture equivalent percentage is less than

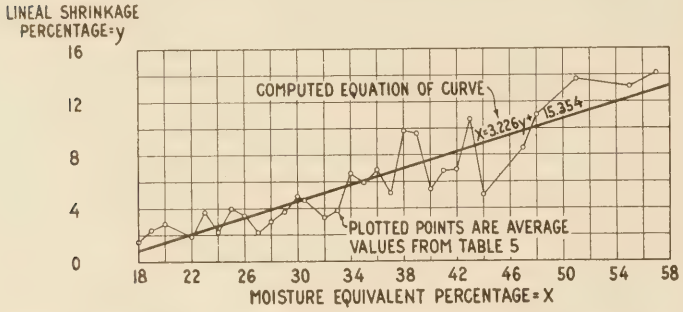


FIG. 10.—Lineal shrinkage percentage curve computed from results obtained from tests of 176 subgrade soils in Oregon and Washington

20 the density and possibly the bearing power of a soil do not seem to be decreased perceptibly by the addition of water until the moisture content is made greater than the total voids in the soil.

3. Defining the term "stability ratio" as the actual moisture content percentage of the soil divided by its moisture equivalent value, the field investigations in the States of Oregon and Washington seem to indicate that the bearing power of a soil is relatively low when the stability ratio is greater than unity. When the stability ratio is less than unity, existing subgrades are generally well compacted, firm and hard. The application of the stability ratio is limited to soils with moisture equivalent percentages greater than 20.

4. When the moisture equivalent percentage of a soil is greater than 20 the moisture equivalent percentage seems to represent the extreme limit that the moisture content of a subgrade should be permitted to reach.

5. The lineal shrinkage percentage test detects poor subgrade soils which pass a favorable moisture equivalent test or vice versa.[3]

6. The lineal shrinkage of a soil with a moisture equivalent percentage of less than 20 is usually too small to be measured. According to the curve in Figure 10 the shrinkage will be zero when the moisture equivalent percentage is 15.4 per cent. This curve was computed from the results of 176 tests. An original and check run was made for each test and the average result used. For all practical purposes it is believed that zero shrinkage may generally be assumed to occur when the moisture equivalent percentage is equal to or less than 20. Table 5 gives the maximum, minimum and average values of the lineal shrinkage percentages for the corresponding moisture equivalent percentages expressed to the nearest unit figure.

7. When the lineal shrinkage percentage is less than 5 per cent, the subgrade soil does not seem to require special treatment or protective measures to prevent the shrinkage or swell from reducing the life of the road surfacing.

[3] A soil with porous grains might have a high moisture equivalent and a relatively low shrinkage percentage. Soils with a high shrinkage percentage contain larger percentages of clay and heave readily when frozen. In the State of Washington 81 per cent of the cement concrete pavement slabs are cracked in the eastern portion where the frost is severe, while in the western third of the State where the frost is severe only 55 per cent of the slabs subjected to heavy logging traffic are cracked and 15 per cent of those not subjected to heavy logging traffic (1922 data.)

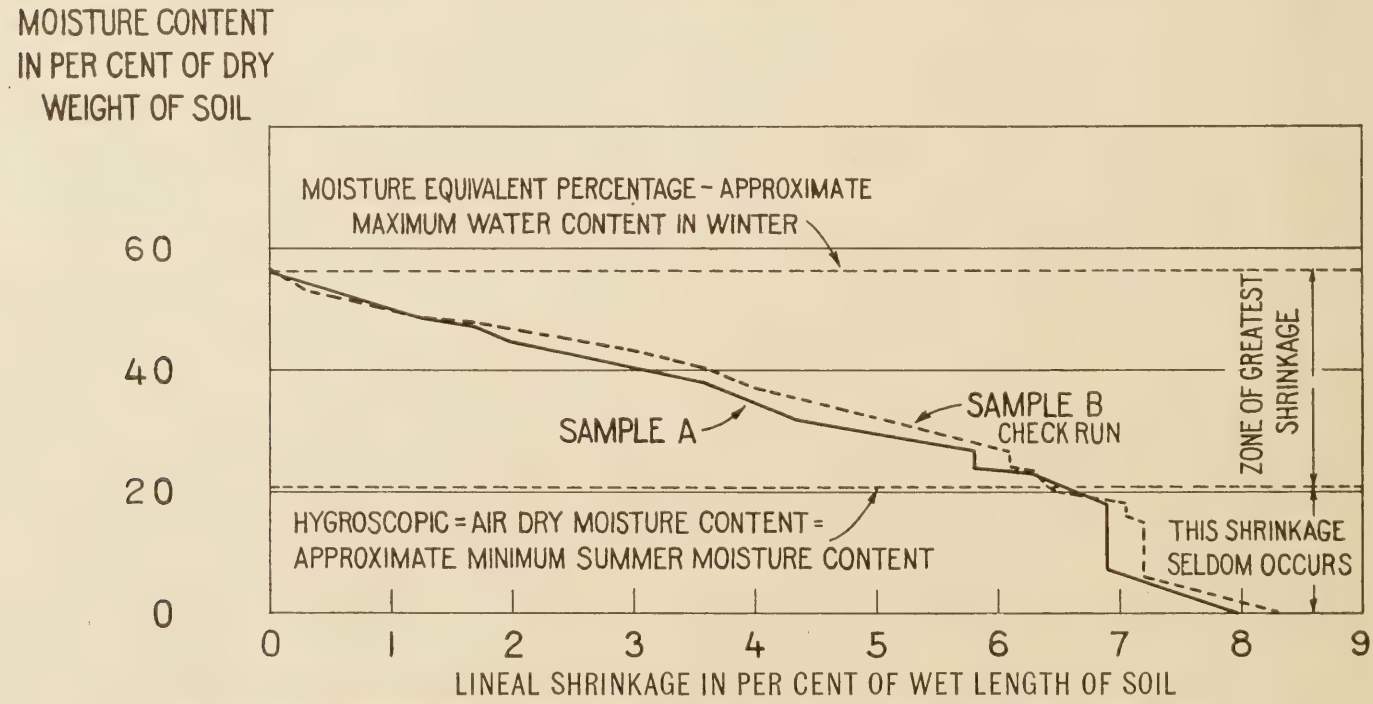


FIG. 11.—Relation of lineal shrinkage to moisture content on sample of clay subsoil from Pacific Highway near Woodland, Wash.

8. When the lineal shrinkage percentage is greater than 5 per cent,[4] it seems that special precautions should be taken to insure a road surface against failure due to subgrade soil movement. The moisture content of the soil when in excess of capillary moisture may be reduced by surface or tile drains or both. The pavement may be strengthened by increased depth, steel reinforcement, or a suitable subgrade. A sand cushion may be provided under the surface or the soil may be treated. It is to be noted that the actual variation in the moisture content of the soil determines the amount of shrinkage or swelling. Only in rare instances do soils dry out completely and reach the maximum possible shrinkage percentage. Figure 11 illustrates this.

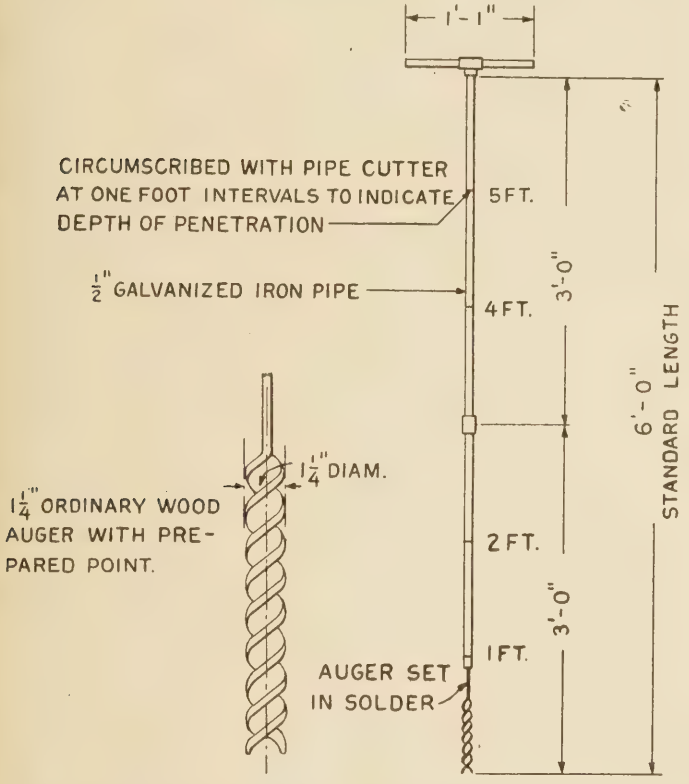


FIG. 12.—Soil auger. Extra pipe lengths may be added in 3-foot sections. The total practicable penetration is 18 feet. The point is prepared as follows: (1) Anneal; (2) saw or drill out concave center; (3) trim with round file, without bending or altering conformation of prongs; (4) sharpen ends of two prongs to chisel points, ¼-inch wide, with flat surface in plane perpendicular to axis of drill

9. Embankments across clay soil lowlands which are subject to flood should, wherever possible, be constructed with soil hauled from the surrounding hills rather than by side borrow. The lowland clay generally has a high lineal shrinkage percentage, while the upland soil has usually a much lower shrinkage value. The core of the fill may be made by side borrow and sloped with upland material, if the cost of the long haul prohibits the formation of the entire embankment from the upland soil.[5]

TABLE 5.—*Lineal shrinkage percentages based on tests of 176 soils in Oregon and Washington*

Field moisture equivalent to nearest unit	Lineal shrinkage			Number of tests	Field moisture equivalent to nearest unit	Lineal shrinkage			Number of tests
	Maximum	Minimum	Average			Maximum	Minimum	Average	
Per cent	*Per cent*	*Per cent*	*Per cent*		*Per cent*	*Per cent*	*Per cent*	*Per cent*	
18	3.0	0.0	1.5	2	38	12.5	6.4	9.8	4
19	2.4	2.4	2.4	1	39	10.6	8.3	9.6	5
20	3.4	2.4	2.9	2	40	9.4	1.9	5.4	4
21				0	41	11.2	1.0	6.8	6
22	3.1	1.1	1.9	6	42	11.3	3.7	6.9	5
23	6.7	2.5	3.7	6	43	11.2	10.3	10.7	3
24	5.3	.2	2.1	9	44	6.4	3.6	5.0	2
25	6.5	1.7	4.0	9	45				
26	10.9		3.5	14	46				
27	4.7	.5	2.1	6	47	12.2	5.6	8.5	3
28	5.2	1.6	3.0	11	48				
29	7.5	2.6	3.7	5	49	11.8	10.2	11.0	2
30	7.0	2.8	4.9	11	50				
31	9.0	1.0	4.6	16	51	13.7			1
32	4.9	2.1	3.3	8	52				
33	7.9	.6	3.8	5	53				
34	12.9	1.3	6.6	10	54				
35	8.2	2.1	5.9	6	55	13.1			1
36	9.9	3.5	6.9	8	56				
37	8.8	1.0	5.1	4	57	14.1			1

EQUIPMENT REQUIRED FOR A ROAD PROJECT SOIL SURVEY

The apparatus and equipment required to make subgrade soil surveys similar to these described is as follows:

1 automobile (preferably a closed car, since the best investigations of drainage are made during rainy weather).
1 Soil auger (see fig. 12).
6 dozen galvanized seamless salve boxes 3 inches in diameter and 2½ inches deep with covers.
1 small camp oven, preferably equipped with a thermostat.
1 electric hot plate for heating oven.
1 small pick.
1 shovel.
1 set of equipment for moisture equivalent and shrinkage tests as shown in Figure 2.

After the moisture equivalent and shrinkage values of typical soils in a region have been determined, it is necessary to make routine tests only in rare instances. An experienced investigator is able to identify silts, loams, clays, sands, etc., by rubbing between the fingers and it is remarkable how closely the moisture equivalents may be estimated by inspection.

[4] This is equivalent to a volumetric shrinkage factor of about 14 per cent and corresponds approximately to a moisture equivalent percentage of 30.

[5] One of the most serious subgrade failures in the Pacific northwest occurred on the Pacific Highway between Centralia and Chehalis, Wash. The fill had been made by side borrow with the heavy Chehalis clay soil which had a moisture equivalent of 55 per cent and a lineal shrinkage percentage of 13 (equivalent to a volumetric shrinkage percentage of 34). The berms left at the toe of the slope of the fills were too narrow. The embankment was distorted when the soil was swelled annually by flood waters from the Chehalis River. The fill sloughed into the borrow pits and left the cement concrete pavement unsupported under the edges in many places. The impact and weight of the traffic resulted in many longitudinal and transverse cracks and broken corners. The character of the concrete pavement was good. This was a typical subgrade failure. To remedy this failure the State highway department has widened the old clay fill by placing a layer of upland soil from 4 to 8 feet in thickness along the side slopes. This new fill soil has a comparatively low shrinkage percentage. After ultimate settlement of the new embankment, the existing pavement will be resurfaced with a cement concrete pavement 20 feet wide. Precaution will be taken to provide a sliding plane between the old and new pavements.

THE REGULATION OF MOTOR VEHICLES AS COMMON CARRIERS

By HENRY R. TRUMBOWER, Economist, U. S. Bureau of Public Roads

IN 1907, about the time when automobiles began to come into general use, the States were still debating whether public service corporations furnishing light, heat, power, water, and telephone service and the traction lines should be placed under the regulation of the States by public utility commissions. By that time most of the States had established railroad commissions which regulated the rates and service of steam railroads and there was a general feeling that these other public utility enterprises should be similarly regulated both as to rates and service. Wisconsin and New York were the first States to extend this jurisdiction of the State and both enacted laws which gave these regulatory powers to railroad commissions which already existed.

When the automobile began to be used as a common carrier, either as a jitney competing with city street-car service or as a bus between cities or as a truck carrying persons and property for compensation, it was recognized that this was a new type of public service. Cities first began regulating these new transportation agencies and subsequently State legislatures began passing laws which extended their jurisdiction and regulatory power to the motor vehicle operated as a common carrier in like manner as to the rail transportation service. There has been considerable discussion as to the policy of extending a State's regulatory power to the motor vehicle. As yet there is no complete agreement on the subject and not all the States have gone so far as to regulate common carrier motor vehicles to the same degree as steam and electric railroads.

The principal arguments in favor of State regulation of automobile carriers may be summarized as follows: That motor vehicles operating as common carriers should be regulated the same as other public transportation agencies and in that manner travelers and the shipping public could be assured regular, adequate, and efficient service including at the same time the highest degree of safety and responsibility; that where motor vehicle common carriers are apt to bring about competitive conditions which are ruinous to other carriers, the State can determine what is to the best interest of the public in the long run and protect that agency which it is shown deserves protection and whose service is needed by the public; that there should be placed upon the common carrier motor vehicle those duties and obligations which are commensurate with the benefits obtained from the public which furnishes the highway and allows it to be used for gain and profit; that public regulation is desirable in order to protect from irresponsible competitors those motor vehicle common carriers which have established themselves and are furnishing satisfactory service.

IS REGULATION NECESSARY IN ABSENCE OF MONOPOLY?

The attitude of those opposing this type of legislation finds its expression in the message of the governor accompanying the veto of a motor-vehicle regulation measure passed by the Wisconsin Legislature. He said: "My objection to this bill is fundamental. Jitneys and busses may be operated by anyone upon the public highways and streets, and therefore there is no opportunity to create a monopoly. Free competition prevails, and thus rates and services are regulated by the natural law of competition. It is quite different with respect to a street railway, an interurban railway, or a railroad. When either of those occupies a territory, there is no opportunity for a competitive, like system to come into that territory. There is a limitation on the number of street railways or interurban lines that may occupy the field of transportation, and so the transportation companies hold the field against all others; and the reason for regulating them is because of the fact that they possess a monopoly, affording them the right, in the absence of regulation, to arbitrarily discriminate, grant rebates and other special favors, charge an excessive fare, and give inadequate service. The legislature, therefore, wisely provided for the regulation of such monopolies. The motor vehicles have come to stay; they are the beginning of a transportation system about which it is dangerous to prophesy. They may in the future be displaced by more modern systems of transportation. The old canal companies fought for their existence when the railroads came, but the building of railroads could not be obstructed merely for the purpose of preserving the canal companies. * * * I do not believe that it is any part of the State's duty to obstruct or hinder that means of conveyance. So long as the motor vehicles do not possess a monopoly, there is no ground for regulating them, except to protect the safety and health of the traveling public. To regulate them from the standpoint of protecting some other business, is to interfere with free competition, not in the interests of the general public, but for the special protection of some specific business."

There is a certain amount of truth in the statement that public regulation is not necessary where monopoly conditions do not prevail. Regulation on the part of the Federal Government and the State governments was undertaken for the purpose of protecting the public against unreasonable rates and discriminatory practices which grew up under monopoly conditions. It seems, therefore, logical that when and if competitive conditions are restored regulation can be given up. In this connection it should, however, be observed that the motor vehicle as a common carrier makes its appearance as a competitor in the entire field of transportation, including steam railroads and electric city and interurban railroads. To keep on regulating one form of transportation as to rates and service and allow the new type of competitor free rein without placing upon him any degree of restraint or responsibility is an unfair practice and will lead sooner or later to conditions which will be intolerable from the public point of view. The public is entitled to adequate and continuous service at reasonable rates; unlimited competition on the part of the motor vehicle with the common carrier which is regulated by the public will in the long run seriously affect the service and may force that type of carrier to curtail or abandon its service which is most essential to public needs.

MOTOR VEHICLE COMMON CARRIERS REGULATED IN 28 STATES

At the end of 1923 there were 28 States[1] which had adopted the definite policy of regulating motor vehicles engaged in common carrier service and through the State public service commissions were exercising control over the routes, service, and fares. Many of the cities exercise control over so-called jitney operation even though the State has not enacted any legislation pertaining to motor vehicle common carrier service on the public highways. There are also certain States which have not gone so far as to put automobiles carrying passengers and freight for hire into the public utility class which at the same time require such operators to carry liability insurance and give bonds. As yet the Federal Government has not taken any steps to regulate automobile carriers although there are a great many who engage in interstate business. Where railroad companies have made arrangements to forward freight shipments by rail and motor truck the Interstate Commerce Commission has taken the position that the commission's jurisdiction does not extend to that part of the service carried on by motor truck over the highways.

The right of the State to regulate the activities of motor vehicles engaged in common carrier operation is well established; this is true whether the State does it directly through a regulating commission or through a city council which derives its powers from a charter granted by the State. The regulation and control of the jitney has been held by the courts to be a legitimate exercise of the police power. *Memphis* v. *State ex rel. Ryals.*, 133 Tenn. 83; *Ex parte Dickey*, 76 W. Va. 576; *Auto Transit Co.* v. *Fort Worth (Texas)*, 182 S. W. 685; *Thielke* v. *Albee*, 79 Ore. 48; *Huston* v. *Des Moines*, 176 Iowa 455; *Green* v. *San Antonio (Texas)*, 178 S. W. 6; *Smith* v. *Nunnelly (W. Va.) P. U. R.*, 1915E 177. Under the police power of a State the legislature may prescribe the number, character, routes, rates, and hours of service of common carrier vehicles on highways; this power can be delegated to a city council or to a public service commission.

In framing laws of this character it is necessary in the first place to name and describe definitely the type of motor vehicle and the nature of the service which is to be regulated and supervised by the State. The State of Washington has adopted a very comprehensive definition covering this matter; its jurisdiction extends over all "auto transportation companies" and these are defined as "every corporation or person, * * * owning, controlling, operating, or managing any motor propelled vehicle not usually operated on or over rails used in the business of transporting persons, and, or, property for compensation over any public highway in this State between fixed termini or over a regular route, and not operated exclusively within the incorporated limits of any city or town; Provided, that the term auto transportation company, as used in this act, shall not include corporations or persons * * * in so far as they own, control, operate, or manage taxicabs, hotel busses, school busses, motor propelled vehicles, operated exclusively in transporting agricultural, horticultural, or dairy or other form of products from the point of production to the market." [2]

One of the frequent questions which commissions and courts have to decide is whether or not a specific motor vehicle is operated in such manner so as to bring it within the State's regulatory powers. Statutory definitions which are clear and comprehensive are of great assistance to those who are responsible for the administration of the law. That the State has the power to regulate common carriers is no longer open to argument, but a commission can regulate only those common carriers which have been definitely named and included by definition in the statute conferring jurisdiction to the regulatory agency.

An example of this came up in California. The California commission held that a motor bus line, auto truck line, or auto stage line engaged in transportation for hire was not a public utility under the California act although it might be a common carrier. *Western Assoc.* v. *Hackett (Calif.)* P. U. R., 1915F. 997. The position taken by the commission was reversed by the State supreme court when the case came before it on appeal; the court held that such motor vehicle lines were "transportation companies" and subject to the control of the commission because the constitution from which the commission received its authority gave the commission the power to regulate railroads and "other transportation companies." *Western Assoc.* v. *Railroad Commission*, 173 Calif. 802. In following the rules of construction the court must have concluded that motor vehicle common carriers resembled "railroads" closely enough so as to come within the category of "other transportation companies." In a great number of States which have had public utility acts and where power was given to commissions to regulate railroads, both steam and electric, the laws have been amended by adding motor vehicles engaged in common carrier service and by putting them in the same class as railroads. The Colorado Public Utilities act defines the term "common carrier" in saying: "The term 'common carrier' when used in this act includes every railroad, corporation * * * and every other corporation or person affording a means of transportation by automobile or other vehicle whatever, similar to that ordinarily afforded by railroads or street railways and in competition therewith." [3]

The statute of Maryland, which was one of the first States to regulate the motor vehicle as a common carrier, provided that the term "common carrier" includes all persons * * * operating automobiles and motor cars or motor vehicles for public use, in the conveyance of persons or property.[4] The completeness of the jurisdiction which the States have because of statutory enactments depends wholly upon the specific provisions of the law in each case. In most States the powers granted to the commissions are far reaching in character; in some States the jurisdiction applies to passenger motor vehicles alone; in New Jersey the commission has jurisdiction over and can regulate only those auto busses which operate over routes parallel to a street railway line or traction railway.[5] The Ohio law limits the commission to a supervision of the rates and service and safety of operation of common carrier motor vehicles; the control of competition with other transportation agencies is not delegated to the commission.[6]

[1] Arizona, California, Colorado, Connecticut, Georgia, Illinois, Iowa, Maine, Maryland, Michigan, Montana, Nevada, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Virginia, Washington, West Virginia, Wyoming.

[2] Chapter III, sec. 1, Laws of Washington, 1921.

[3] Chap. 127, sec. 2-E, Laws of Colorado, 1915.

[4] Chap. 180, sec. 1. 5, Laws of Maryland, enacted 1910, amended by Chap. 445, laws of 1914.

[5] Chap. 149, sec. 15, laws of New Jersey, 1921.

[6] Act July 26, 1913.

CERTIFICATES OF PUBLIC CONVENIENCE AND NECESSITY

Wherever State commissions exercise complete control and supervision of common carrier motor vehicle transportation it is necessary that any one desiring to engage in this kind of service obtain from the commission a permit which certifies that the holder has the right to give service of a certain character between two definite terminals. This permit or certificate is not issued unless it is shown that public convenience and necessity require this new service or operation and consequently the certificates are generally called "certificates of public convenience and necessity." This procedure is taken directly from the railroad and public-utility laws and is the basis of the monopoly feature of such enactments. The New York Public Service Commission in one of its decisions has made a very good attempt at defining this term. "Taking the phrase as an entity," the commission says, "it does not mean to require a physical necessity or an indispensable thing. We take it that for such purposes as are involved in this and similar applications, a public convenience and necessity exists when the proposed facility will meet a reasonable want of the public and supply a need, if existing facilities, while in a sense sufficient, do not adequately supply their need." [7] In most States where laws have been passed requiring that no motor vehicles operate as common carriers until they have secured public convenience and necessity certificates it is provided that those operating at the time the law becomes effective are considered as being within their rights. The certificates may be good only for the year issued or they may be granted for an indefinite period; if granted for a year they are ordinarily renewed at the end of the year without any further formalities.

A good deal of the litigation before commissions and courts involving the regulation of the operations of motor vehicles as common carriers pertains to contests over the granting of a certificate of public convenience and necessity. Practically all of these cases grow out of applications to operate motor bus lines. The cases can be grouped into two classes; *first,* where an applicant seeks the right to operate in a field which is already occupied; *second,* where there are several applicants seeking the right to operate in an unoccupied area. The competition which would be set up in this first group of cases is with street railways in cities or in suburban sections, with steam railroads, and with other common carrier motor vehicles.

STREET RAILWAYS ENTITLED TO PROTECTION AGAINST LOSS OF SHORT-HAUL FARES

The revenue feature is usually the one which receives the most consideration in determining whether or not a permit should be granted to operate a motor bus in direct competition with urban and inter-urban electric railroads. On account of the fact that a uniform flat rate of fare is being generally charged on street railway lines and that passengers are carried long distances as well as short distances for the same fare, the street railway finds its revenues seriously depleted if its short-haul passengers are taken away from it by a motor bus and the rate of fare for the other passengers may have to be increased, or at least it will make it impossible to reduce fares. For this reason public utility commissions in their decisions in such cases have taken the stand that street railways were entitled to protection up to a certain point. The loss in earnings of a street railway brought about through the competition of motor bus operation would result in preventing the street railway from securing the needed capital for extensions and betterments and the public would finally suffer. The check upon unwise competition in the opinion of the New York commission is abundantly justified from the point of view of public advantage. *Petition of Gray (N. Y. 2d Dist.) P. U. R. 1916A. 33.* That same commission holds that motor busses should be confined to streets and neighborhoods which are not served by street railroads except in cases where existing street railroads refuse to or can not supply the service requirements. *Petition of Gray (N. Y. 2d Dist.) P. U. R. 1916A. 33.*

In most cases it has been held that under the conditions existing in the larger cities motor-bus service can not be substituted wholly for street-car service because it would inadequately meet the public needs. At the time when the Oregon commission was considering an application for an increase in street railway fares in the city of Portland a suggestion was made that motor-bus transportation could be introduced and thus do away with street railway operations. After making a comprehensive study of the practicability and economy of motor-bus transportation the commission concluded that in these grounds it would not be justifiable to make a substitution. "Even on the more profitable lines of traffic," the commission said, "it appears that the cost would equal, if not exceed, that of the street railway, and because of the narrowness of Portland's streets the congestion of traffic which would be occasioned thereby would make it impracticable if not prohibitive." *Re Portland Railway, Light & Power Co. (Oreg.).*

According to the New York commission there is justification in the competition between a line of motor busses and a street railway line "where it appears that there is such a divergence of routes and so much greater convenience afforded by the stage route that it may fairly be said that it supplies a want of the public not already adequately met." *Re Troy Auto Car Co. (N. Y. 2d Dist. P. U. R.) 1917A 700.* Just what distance there must be between the route of the motor-bus and street-car line so that there will not be any direct competition is a matter which must be determined in each individual case. It has been held that an auto-bus line operating over a route which was 2,500 feet from the nearest street railway line did not improperly interfere with it and under those conditions a certificate was granted. *Re Woodlawn Improv. Transportation Corp. (N. Y. 2d Dist.) P. U. R. 1916D 1.*

COMPETITION OF MOTOR AND RAILROAD

When the operation of common carrier motor vehicles comes into competition with paralleling steam railroads practically the same policy is followed as in the case of competition with street railways. Where the service of the steam railroad is inadequate and unsatisfactory permits are granted. *Re King. (Calif.) P. U. R. 1919F 377.* Not many cases of this kind have arisen because the service of the motor-bus lines is in most instances purely local in character.

Commissions have uniformly held that where motor-bus lines are operating and giving satisfactory service they should be protected from competition of other operators. *Re Automobile Stage Line (Ariz.) P. U. R. 1918B 292.* If it appears, however, that there is enough business to warrant the establishment of a second line and the line already operating does not

[7] Re Troy Auto Car Co. (N. Y. 2d Dist.), P. U. R. 1917A, 700.

properly serve the public, certificates of public convenience and necessity are issued to applicants authorizing competitive service.

Where there is an unoccupied field and there are several applicants seeking permits to operate and it appears that the prospective business warrants only one line of motor busses, the commission has to take into account the relative ability of the applicants to furnish the required service. *Re King (Calif.) P. U. R. 1917F 377; Re Chicago Motor Bus Co. (Ill.) P. U. R. 1918C 320.* Such considerations as the financial responsibility of the applicants, the type of equipment, the proposed rates and schedules are all matters which are given due weight.

Through regulations and the promulgation of rules the State commissions supervise the operations of motor busses; speed limits are established, provisions are made for all kinds of safety measures, rules of conduct and the hours on duty of drivers are definitely prescribed, the capacity loads are fixed, and all manner of precautions are taken for the benefit of the traveling public.

In none of the formal proceedings have any definite principles been established as to the maximum rate of return which should be allowed to this new class of common carriers and public-utility enterprises. The business is new, and very little authentic information has been collected which would indicate what the return should be. The capital requirements are not so large as in other kinds of public utility undertakings. At the same time the business has been conducted in many instances by individuals who keep few accounts and who, at the best, have but a limited conception of the intricacies of cost accounting. Rate cases as such have not found their way to the dockets of public utility boards and commissions. Because of the lack of rate controversies the valuation of the property of these carriers has not been necessary.

The regulatory laws of the various States provide that annual reports shall be filed in accordance with the requirements prescribed by the commissions. These reports at present contain fairly accurate data as to revenue; when it comes to a classification of operating expenses there is an evident weakness. The item of depreciation usually receives very little attention; there is also noted a confusion in the minds of many of the small operators between wages and salaries on the one hand and return on the other. In those States where street railway companies have, either directly or indirectly, gone into the business of operating motor busses to supplement their rail service, reports and financial statements are filed which are properly made out by the accountants and clerks familiar with public utility cost accounting systems.

According to the information obtained from a number of State commissions which regulate the operations of all common carrier motor vehicles there is a tendency for the individual operators to be taken over by corporations organized for this purpose; consolidation of small operators is also noted. Large companies are appearing which control the routes in a given section of a State. The motor-bus business may pass through the same consolidation movement which took place in the early days of the street railway business.

TRAFFIC CONTROL AND SAFETY

(Continued from page 9)

tinuous routes east and west, and the even numbers to similar routes north and south. A traveler from the Atlantic seaboard to the Pacific would know that he was going west so long as he continued on an odd-numbered route, even though he had no map. The odd numbers would take precedence over the even numbers where a diagonal or cross route was used by both the north-and-south and east-and-west route.

Guide sign used in Pennsylvania giving direction and distance

With the aid of a simple diagrammatic map of the system, this arrangement would greatly facilitate travel in all parts of the country with assurance against loss of time or distance.

Beginning with number 100 other routes of the road system could be numbered in each State independently. A traveler on a three-digit route would know that he could not depend on an interstate connection indefinitely across the country.

Some States already have authority to give final designation to the State roads and are awaiting a decision in this matter before proceeding. This plan will be devised to make it possible to eliminate the confusion of multiple numbering and marking now so common. There is at least one road in the country, in a State that has made one of the most successful efforts at designating the State system as such that carries to-day eight different designations because it is a part of eight interstate and State routes. This confusion should and can be eliminated.

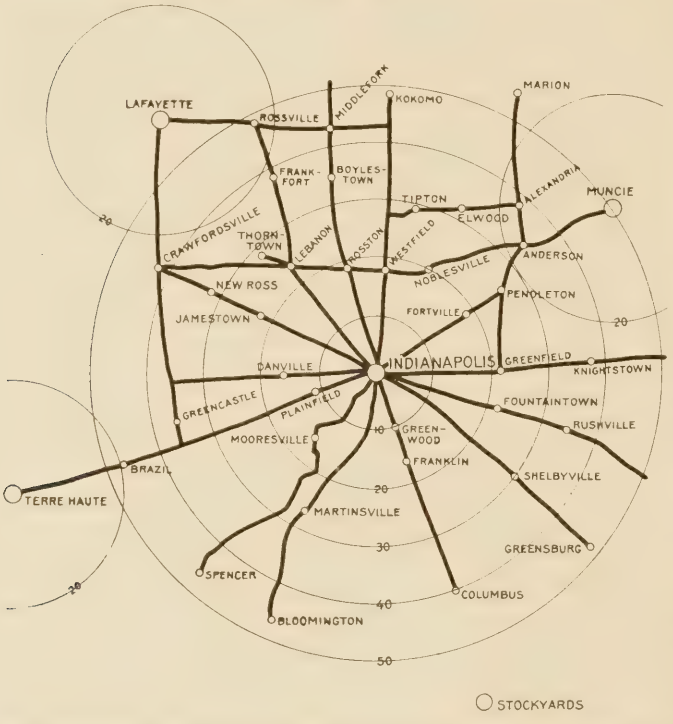
The foregoing brief and general statement of what has been done and of what is being done to promote traffic control and safety on our highways clearly discloses several facts. We have a definite and reasonably complete knowledge of principles and have a means of securing further data. We see that many excellent devices and practices are in use in many of the States, and that were it possible at once to select from each State the best details of design, the best system of marking, the most efficient policing, and to adopt the best traffic regulations already in force, we could construct a code of traffic control and of highway engineering practice that would furnish an almost complete physical and regulatory solution to the problem of securing safety on the open road. The present immediate problem is to secure uniformity and harmony in the adoption of the best practices.

TRANSPORTATION OF HOGS BY MOTOR TRUCK

BUREAU OF PUBLIC ROADS STUDY SHOWS EXTENT OF PRACTICE IN INDIANAPOLIS MARKET

By E. L. BROWNE, Agricultural Economist, U. S. Bureau of Public Roads

HIGHWAY transportation has to-day come to be one of the main pillars of our economic structure. We have seen this development taking place before our eyes during the past ten or fifteen years but we have been able only to sense its proportions as we have seen the streams of trucks passing over the highways carrying the products of farm and factory. There is a real need to know whence these trucks come, where they go, what they carry, and what it costs in order that we may form some sort of estimate of the value of the services they render.



Map showing area from which hogs are trucked into Indianapolis and location of competing markets

The transportation of livestock over the highways to markets where they are butchered has become quite general in the production areas close to such markets, and Indianapolis has been selected for study as sufficiently representative of such practice. In this area a very large proportion of the livestock produced within 50 miles of the city is trucked in and this practice has grown up where a steam and electric service equaled in few agricultural areas has existed for several years, more than twenty such lines entering the city from all points of the compass.

The use of the motor trucks for delivering livestock from the farm to the Indianapolis stockyards began in 1912 and since that time has increased rapidly. In 1913, the first year truck receipts were recorded separately; they amounted to 4.55 per cent of the total, while in 1923 the truck receipts of hogs, cattle, calves, sheep, horses, and mules amounted to 31.7 per cent of the total.

The Indianapolis stockyards, which are the largest east of Chicago, are primarily a hog market. For this reason this discussion will be confined to this class of livestock. The annual receipts of hogs transported by motor truck give an interesting picture of the rapid change which has been taking place since 1913. The volume of such receipts has become so large in recent years that the stockyards company have found it necessary to establish a separate division for trucked-in stock, known as the truck division. The following table gives the official figures for the receipts of hogs from 1913 to 1923 as reported by the auditor of the Belt Railroad & Stockyards Co.:

Receipts of hogs, Indianapolis stockyards, 1913–1923

Year	Total receipts	Truck receipts	Per cent of total
1913	1, 994, 624	90, 821	4. 55
1914	2, 099, 787	96, 591	4. 60
1915	2, 435, 319	136, 447	5. 60
1916	2, 576, 611	173, 191	6. 72
1917	2, 350, 730	271, 994	11. 57
1918	2, 749, 976	462, 313	16. 81
1919	2, 936, 493	711, 212	24. 21
1920	2, 896, 894	791, 988	27. 33
1921	2, 694. 705	808, 595	30. 00
1922	2, 266, 551	734, 280	32. 39
1923	2, 875, 648	934, 960	32. 54

TERRITORY SERVED BY TRUCK

The localities from which hogs are shipped by motor truck and distances from market vary somewhat according to road conditions and seasons. The normal trucking range is within a 50-mile radius of Indianapolis. Ninety per cent of the hogs received from this area are delivered by motor truck. There are scattering shipments from the territory 75 to 100 miles away but normally these shipments move by rail. The condition of the unimproved roads varies greatly with the season of the year. During the late winter and early spring months few haulers will accept shipments originating off the State or county roads, but during the summer and fall months livestock trucks go anywhere. With the number of miles of good roads constantly on the increase in the territory surrounding Indianapolis, the trucking radius is being constantly pushed back to the economic limit of truck haul on improved roads.

While the prevailing rates favor rail shipment for long distances there is another reason why 50 miles is about the limit of livestock hauling, that is the competition of other stockyards located as shown on the accompanying map. Stockyards of fairly large proportions are located at La Fayette, Terre Haute, and Muncie. These markets as a rule take up only local stock most of which is trucked-in.

LIVESTOCK SHIPPING RATES

A satisfactory rate must be one which is low enough to attract business in the face of competition and high enough to yield a reasonable profit. As the business is handled almost entirely by individual truck owners engaged in small scale operation without any central organization there has been no attempt to establish uniform rates. Usually the rate is agreed upon at the time shipment is made, taking into account competitive rates, number, and kind of stock, length of haul, and condition of roads. The following table shows the comparative rail and truck rates for several representative shipping points near Indianapolis.

Truck and rail rates on hogs into Indianapolis

Shipping point	Distance	Rate per hundred pounds				
		Truck	Steam railroad		Traction line	
			Single deck	Double deck	Single deck	Double deck
	Miles	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Danville	20	20	14	12	13	11
Franklin	21	20	14½	12½	13½	.....
Lebanon	27	25	15	13	14½	12
Thorntown	30	30	16½	14½	14½	12
Martinsville	30	30	16½	14½	14½	12
Columbus	41	40	18	16	17	.....
Crawfordsville	45	45	18½	16	17	14
Greensburg	48	50	18½	16	18	.....
La Fayette	68	70	.....	.....	19	18

If every farmer had a full carload of hogs to ship at one time, railroad or traction lines offer, in practically all cases, cheaper rates than the truck haulers. However, there are relatively few farmers who have ready for market at one time a sufficient number of hogs to make up even a minimum carload. Thus the cost per head is often higher by rail, especially when one considers the barnyard to stockyard service which the truck furnishes.

For example, the minimum rate on a single-deck car over the traction line from Lebanon to Indianapolis, a distance of 27.7 miles, is $24.65 (17,000 pounds minimum weight at 14½ cents per hundred pounds). In addition it costs $5 to $8 to hire a truck to haul stock to the local shipping point. A truck which hauls 20 head of hogs weighing 300 pounds a head, charges 25 cents per hundred pounds or $15 for the load.

In cases of this kind the motor truck offers the cheaper transportation and would be chosen by the farmer even were no other advantages offered as is often the case. In the above sample rates it is seen that the truck rates are approximately proportional to distance while the steam railroad and traction line rates increase at a less rapid rate with added distance. When the cost of hauling a truck load of hogs approaches the rate for a minimum carload there is an incentive to pool shipments and accept the trouble of securing cars, loading, marking hogs, or erecting partitions to distinguish ownership in order to secure a cheaper transportation charge.

Charges for truck hauling are paid directly to the truck operator by the commission firm handling the consignment, a corresponding deduction being made from the the shipper's check. In this way the hauler is always sure of his money and is not bothered by having to make the collection, while the shipper is saved the trouble of making payment.

OWNERSHIP AND OPERATION OF LIVESTOCK TRUCKS

The trucks engaged in livestock hauling are owned and operated by men living in the country or small villages in the rural sections. The owner usually makes trucking his sole business but in some cases he may farm a few acres during spare time. There are no fleet organizations operating into the Indianapolis stockyards. Most haulers operate but one truck; now and then one runs two or three trucks. There is an increasing number of farmers who own and operate trucks of their own. At the present time there are no cooperative farmers' organizations operating trucks.

To operate successfully a livestock hauler must keep his truck in use the greatest possible number of days during the year. When there were comparatively few trucks operating it was not uncommon for trucks to average 300 to 325 trips a year; of late so many have entered the business that the average number of trips is being rapidly cut down and the profits of operators reduced. Few operators realize that their fixed operating costs go on whether their trucks are used or not. With competition among haulers increasing yearly many haulers have had to look for other sources of income.

THE RETURN LOAD

The return load offers an extra income which in many cases may be the margin of profit for the year. There are three types of return load carried. First, there are the loads of feeder stock which are picked up at the yards. This class of return load is very profitable as no time is wasted in making up a load and it is unnecessary to clean out the body before reloading. Second in importance is the hauling of feed, which has increased considerably since the Farm Bureau has located its warehouse near the stockyards entrance. The body of the truck is thoroughly cleaned and washed before the feed is loaded. General merchandise is least important and least desirable due to the time lost in collecting a load, as shipments are usually small and scattered over the city. In order to stimulate the return-load movement the rates charged approximate one-half of those charged for the trip to the city.

A central depot where freight could be collected and consigned has never been worked out as there is very little cooperation between various haulers. Such a depot could easily be operated by one man whose duty it would be to receive and route the freight consigned to the depot and it would be of benefit to all parties concerned.

TYPES OF TRUCKS AND BODIES

The popular capacities are the 1, 1½, and 2-ton trucks with very few heavy-duty types in operation. These smaller types are better suited to the average loads of hogs which are shipped than are the larger capacities. The use of trailers rather than large trucks seems to be popular with many haulers.

Solid tires are most generally used. There are, however, many haulers operating in the part of the territory in which the roads are unimproved who prefer pneumatic tires on account of the advantage during the winter and spring months.

The bodies are the regular platform rack, of which the larger types are easily converted into a double-deck arrangement. A few of the large double-decked, 3-ton trucks will haul 40 to 50 head on one load. The table following gives the carrying capacities of various sizes of trucks.

Number of hogs loaded on trucks of various capacities

Capacity in tons	Number of head of 200-pound hogs
1	12
1½	18
2	25
2½	30
3	35
3 (double-decked)	40–50

NOTE.—A single-decked railway stock car will load 70 to 80 head while a double-decked car loads 140 head (200-pound hogs).

During the year 1923, 71,000 truck deliveries, totaling 934,960 hogs, were made, or an average of 13 hogs per truck load.

TRUCK TRANSPORTATION OFFERS ADVANTAGES TO FARMERS

Shrinkage in truck shipment does not vary greatly from rail shipment when the time element in each is the same. Hogs which are trucked in usually show less loss in weight because they have been in transit a shorter time. This does not necessarily mean that the farmer will get more for his hogs than those that have have been delivered by rail. The difference in weight in the two shipments is the difference in "fill" retained by the hogs after shipment. There is no actual difference in the dressed weight of the hogs. Commission men usually know how long shipments have been in transit and are in a position to judge how much a carcass will dress and what they should pay for it.

While no definite figures are available as to the number of "deads" received by the various means of transport, yet it is well known among producers and commission men that there are fewer losses by truck. Trucked-in hogs move by night during warm weather, whereas rail shipments are often loaded and shipped during the heat of the day. According to figures compiled by the United States Department of Agriculture, 1 out of every 319 hogs shipped by rail dies in transit. It is seldom that one sees a dead hog in front of the unloading chutes of the truck division.

Another advantage is that hogs of one shipper are seldom mixed with those of another shipper, which eliminates fighting among strange hogs. While in transit the driver is always on hand to prevent smothering. He also acts as the representative of the shipper at the yards upon arrival of the truck.

Typical trucks used in hauling hogs to the Indianapolis market

The average hog raiser who is fattening 50 to 60 head always finds that some animals fatten more readily than others. The truck can be used to ship those hogs which are ready for slaughter while the others can be held back. To hold the other hogs over this period would be economic loss; it is also the extremely fat hog that dies in transit.

Before the advent of good roads and the motor truck many raisers who marketed but 20 to 30 head sold to a local buyer who assembled car lots and who traded on a wide margin. The local buyer not knowing exactly when he would move his newly acquired stock generally paid 75 cents to $1.25 below the market price. The raiser had also to deliver the stock to the point at which the local buyer planned to assemble the car. This system has entirely changed. The local buyer is at present eliminated within the trucking radius and the producer ships directly to the yards where his stock is sold at the market price.

A glance at the map will show that many farmers live within trucking distance of two or more stockyards. The motor truck allows a farmer to take advantage of whatever yard offers the best price. It is not uncommon for the small stockyards of Lafayette, Muncie, or Terre Haute to become oversupplied, while at a more distant point, such as Indianapolis, the market might be brisk.

A trailer with a cattle rack body used for hauling a few head of livestock

A close study of market prices and tendencies enables many farmers within trucking radius to take advantage of rises in market prices. The farmer by means of a small radio receiving set can catch the market openings and still have plenty of time to truck his stock to the yards before closing time. Many shippers have found it extremely difficult to get cars when the market offers the best opportunities. However, if the farmer owns a truck or can hire one on short notice, as is generally the case within the Indianapolis trucking area, he is in position to take advantage of every opportunity.

That trucked-in lots are often more uniform and sent forward at the most opportune time so that they average a somewhat higher price is shown by the following table which gives the highest sales price for hogs at the Indianapolis stockyards for the month of March, 1924:

Highest daily sale price for hogs at the Indianapolis market during March, 1924

Date	Delivered by rail	Delivered by truck	Date	Delivered by rail	Delivered by truck
1	$7.60	$7.65	18	$7.70	$7.70
3	7.65	7.65	19	7.70	7.75
4	7.70	7.75	20	7.70	7.75
5	7.85	7.85	21	7.85	7.90
6	7.75	8.00	22	7.80	7.90
7	7.75	7.85	24	7.90	7.85
8	7.75	7.85	25	7.65	7.75
10	7.75	7.75	26	7.70	7.70
11	7.90	7.85	27	7.85	7.75
12	7.85	7.90	28	7.75	7.75
13	7.70	7.75	29	7.70	7.75
14	7.65	7.65	31	7.85	7.90
15	7.75	7.70			
17	7.85	7.75	Average	7.756	7.784

HIGHWAY TRANSPORTATION SURVEYS UNDERWAY IN COOK COUNTY, ILLINOIS, AND MAINE

TWO highway transportation surveys similar in nature and scope to the survey now in progress in Pennsylvania (PUBLIC ROADS, June, 1924) have recently been started. A State-wide survey in Maine conducted by the Bureau of Public Roads in cooperation with the State Highway Commission was begun on June 30 and will continue for a period of four months. Data similar in nature to the information being obtained in Pennsylvania and described in the June issue of PUBLIC ROADS are being recorded at 95 observation stations so located as to secure traffic data on all important highways in the State. At 20 stations complete weight information on all motor trucks, as well as complete information on all other types of traffic, is being recorded, the weight information being obtained by the use of portable scales. At the remaining 75 stations complete data, except weights, are being recorded on all types of traffic. Data at all stations are being recorded in such a manner that weights secured at the weighing stations can be imputed to traffic at stations which have no weighing facilities.

Observations are recorded by personnel specially trained for the purpose and organized into parties, each having a certain number of stations to operate. The schedules of these parties are so arranged as to obtain complete information on each station at all hours of the day and night and on each day of the week. Two parties are organized to operate the weight stations, five parties to operate recording stations (stations that do not have weighing facilities) and two parties to operate selected stations during the night hours.

The survey in Cook County, Ill., which is being conducted in cooperation with the Cook County department of highways began on July 7, and will also operate for a period of four months. This survey is similar in purpose and scope to the Pennsylvania and Maine surveys with such modifications as are necessary to provide the data required to solve the special problems of highway development in an area contiguous to a large city. Data will be recorded at 73 stations in Cook County supplemented by 14 stations located within the city of Chicago.

At 17 of the stations in Cook County complete weight information is being recorded on all motor trucks, weights being obtained by the use of portable scales and complete data on all other types of traffic. At the remaining 56 stations complete data with the exception of weight information are being recorded on all types of vehicles. Information is recorded in such a manner that weights obtained at weighing stations can be imputed to the traffic observed at recording stations. At the stations located within the city of Chicago the density of various types of traffic is being recorded.

Approximately 30 men divided into nine parties are employed in recording data. Two parties have been organized to operate the 17 weight stations, four parties to operate 56 recording stations, one party to operate the stations located within the city of Chicago, and two parties to operate selected stations during the night hours. The schedule of these parties is so arranged as to obtain complete records of traffic at each station at all hours of the day and night and on each day of the week.

Investigations are also being made of the effect of traffic density upon the speed of traffic; of the effect of curves, railway crossings, and highway intersections upon traffic congestion; and of the effect of traffic density upon the point of application of wheel loads with reference to the edge of the pavement and the shoulders of the roadway.

A special investigation of motor trucking in the Chicago area is also being conducted. This investigation will include a study of the extent and nature of motor trucking in this area, the organization and operating methods of trucking companies, trucking rates, operating costs, the use of motor trucks in terminal areas, suburban and intercity transportation of freight by motor truck, the nature and extent of competition between highway transportation and rail and water transportation of freight and passengers, and of marketing by motor truck. This study is being made by special investigators who will interview truckers and shippers throughout the area and gather data on this problem from all available sources.

C. A. HOGENTOGLER TO SERVE WITH ADVISORY BOARD ON HIGHWAY RESEARCH

C. A. Hogentogler, of the United States Bureau of Public Roads, has been granted leave of absence in order to conduct for the Advisory Board on Highway Research of the National Research Council a fact-finding survey of the economic value of reinforcement in concrete pavements. This survey is to be national in scope, and will be conducted in cooperation with interested agencies. It is proposed to cover the various soils, traffic, and climatic conditions throughout the United States.

Mr. Hogentogler has had 15 years of experience in highway construction and highway research which well qualifies him to take charge of the present investigation. After graduation from the Pennsylvania State College, and a short period with the Pennsylvania Steel Co., he was with the Pennsylvania State Highway Department, followed by several years on street and road construction with the borough of Columbia, Pa. For two years he was assistant professor of civil engineering at the University of Idaho. He was then engaged in research with the United States Bureau of Standards, and finally with the United States Bureau of Public Roads, in which organization he has been for the past six years.

During this period Mr. Hogentogler has been actively engaged in a number of important highway researches. These include the first impact and wear tests at the Arlington experiment station and the tests to determine the cushioning properties of tires now being conducted by the United States Bureau of Public Roads in cooperation with the Rubber Association of America and the Society of Automotive Engineers. In 1923 Mr. Hogentogler, as representative of the Bureau of Public Roads, conducted the study made in cooperation with the Advisory Board on Highway Research which resulted in the publication by the National Research Council of its Bulletin No. 35, entitled "Apparatus Used in Highway Research Projects in the United States."

Mr. Hogentogler is the author of a number of important research papers which have appeared in PUBLIC ROADS and which have been reprinted in various technical periodicals. He is a member of the American Concrete Institute and an associate member of the American Society of Civil Engineers.

ROAD MATERIAL TESTS AND INSPECTION NEWS

CONCRETE TEST ROAD IN PENNSYLVANIA

The Pennsylvania State highway department and the United States Bureau of Public Roads are cooperating in the construction of a concrete test road located on State Route No. 50 in the vicinity of Harrisburg, Pa. The project selected is approximately 1,700 feet in length and its site is on a silty loam soil through swampy land.

The purposes of the test road are as follows:

1. To determine the action of a concrete pavement with a 5-inch center thickness and 8-inch edge thickness (8–5–8 section) under a 26,000-pound gross load.
2. To determine the influence of subgrade material on the strength of the pavement.
3. To obtain further data on balancing the cross-section design.
4. To determine the effectiveness of the tongue-and-groove type of longitudinal joint.

Six different types of subgrades have been prepared. They are as follows: Old macadam road scarified and rerolled, sandy loam, shale, clay, clay overlaid with 4 inches of sand-clay mixture and clay overlaid with 4 inches of cinder-clay mixture.

Concrete construction is being carried out in the usual manner, and at approximately the center of each subgrade section a transverse expansion joint is being provided. Adjacent to this expansion joint and on one side of the longitudinal joint over a length of 20 feet, inserts are being placed in the slab in such a manner that strain gauge readings may subsequently be obtained both for the top and bottom of the slab.

Control specimens, consisting of beams and cylinders, representative of the particular portion of the pavement in which the strain gages are to be installed are being made. These specimens are to be tested and broken at the ages of 15 days, 28 days, 6 months, and one year, for the determination of the modulus of elasticity, the modulus of rupture and the compressive strength of the concrete.

The pavement when completed will be subjected to heavy truck loads up to 26,000 pounds gross. Stress readings will be obtained with the truck run near the edge and at the center of the road. The truck will be run during the summer and during the time of the spring thaw. Field determinations of subgrade moisture and bearing value of the soil will be made on the days stress readings are obtained.

From the results of the above tests it is hoped that answers will be supplied to the following questions:

1. Is an 8–5–8 section adequate for occasional 26,000-pound traffic?
2. What influence has the subgrade on the strength of the slab?
3. Will a 4-inch layer of good material improve the strength of a concrete road when laid on a poor subgrade material?
4. Is an 8–5–8 section a balanced design or should the center and edge thicknesses be adjusted?
5. How much of the load does the tongue-and-groove type of longitudinal joint transmit from one side of the slab to the other?
6. If an 8–5–8 section is not safe under a 26,000-pound load, what is the safe load under spring conditions and under ordinary conditions?

COMMITTEE ON TESTS AND INVESTIGATIONS, A. A. S. H. O., MEETS AT BUREAU OF PUBLIC ROADS

A meeting of the Committee on Tests and Investigations of the American Association of State Highway Officials was held at the Bureau of Public Roads on June 23 and 24, 1924. The following States were represented at the meeting:

Delaware, Robert Schmidt, testing engineer.
Florida, Harvey A. Hall (represented by R. L. Jenkins).
Illinois, H. F. Clemmer, engineer of materials.
Iowa, R. W. Crum, engineer of materials and tests.
Kansas, C. H. Scholer, engineer of tests, Mr. Dolly.
Maryland, Dean A. N. Johnson.
New Hampshire, W. F. Purrington, chemist and testing engineer.
New Jersey, R. B. Gage, chemical engineer; J. G. Bragg, testing engineer; Mr. Baughmann.
North Carolina, R. L. Oberholzer.
New York, J. E. Myers, chemist; W. L. Blaum, representing Mr. Treadwell.
Ohio, A. S. Rea, engineer of tests.
Pennsylvania, H. S. Mattimore, engineer of materials; M. H. Ulman, assistant engineer of materials.
Tennessee, O. H. Hansard, chemical engineer.
Virginia, Shreve Clark, assistant engineer.
West Virginia, R. B. Dayton, materials engineer.

The Bureau of Public Roads was represented on the committee by Messrs. Smith, Milburn, Anderton, and Jackson.

The committee discussed and prepared tentative specifications for various types of bituminous and nonbituminous road materials. Among the materials considered were cement, stone, gravel and slag, sand as fine aggregate, reinforcing steel, culvert pipe, wire rope, asphalt, tars, bituminous premolded joints, and paint. After specifications for these materials have been finally adopted by the committee it is planned to present them to the American Association of State Highway Officials through its committee on standards for final action.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1924

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

STATUS OF FEDERAL AID HIGHWAY CONSTRUCTION

AS OF

JULY 31, 1924

GOVERNMENT PRINTING OFFICE

STATES	FISCAL YEARS 1917-1924			FISCAL YEAR 1925									BALANCE OF FEDERAL AID FUND AVAILABLE FOR NEW PROJECTS	STATES
	PROJECTS COMPLETED PRIOR TO JULY 1, 1924			PROJECTS COMPLETED SINCE JUNE 30, 1924			*PROJECTS UNDER CONSTRUCTION			PROJECTS APPROVED FOR CONSTRUCTION				
	TOTAL COST	FEDERAL AID	MILES	TOTAL COST	FEDERAL AID	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES		
Alabama	$ 4,598,721.63	$ 2,186,247.54	464.1	$ 189,707.91	$ 94,229.55	36.9	$ 15,163,939.72	$ 7,415,796.02	843.8	$ 287,894.71	$ 114,403.64	7.0	$ 1,442,286.25	Alabama
Arizona	8,338,365.41	4,287,683.88	527.8	249,398.74	124,699.37	16.3	2,126,052.16	1,289,917.23	148.5	266,850.29	163,072.20	32.7	1,630,328.32	Arizona
Arkansas	11,094,751.31	4,424,345.63	944.4	122,739.41	50,850.67	4.9	6,096,478.87	1,965,651.70	338.0	1,997,568.97	945,362.19	81.2	1,676,189.91	Arkansas
California	12,999,075.03	5,647,148.17	533.7	750,456.11	395,623.78	25.1	12,754,895.61	6,803,638.77	439.8	1,743,516.22	869,300.62	38.3	3,377,594.66	California
Colorado	8,108,070.31	4,029,898.97	502.6				5,387,187.51	2,905,223.07	191.6	444,999.28	249,731.34	23.4	2,375,027.62	Colorado
Connecticut	3,062,872.02	1,269,556.60	73.6	199,024.56	98,423.00	4.9	2,839,677.86	930,529.90	47.3	95,905.81	25,301.25	1.6	1,057,382.25	Connecticut
Delaware	3,056,832.22	1,007,714.83	72.5				1,096,672.50	420,933.60	27.6	458,964.00	164,700.00	11.0	146,181.57	Delaware
Florida	961,134.07	461,470.92	48.8				9,190,174.82	4,506,551.34	259.3	398,642.71	171,123.94	10.2	1,147,740.80	Florida
Georgia	17,167,373.32	7,956,805.20	1214.2	245,795.65	122,013.76	18.6	8,894,094.72	4,303,227.15	720.1	1,498,002.68	688,913.25	115.5	1,379,937.64	Georgia
Idaho	8,181,697.92	4,092,395.52	506.8	82,328.24	46,817.62	0.1	1,452,536.71	841,813.01	101.2	1,006,048.61	548,146.93	59.7	1,048,538.92	Idaho
Illinois	26,964,706.06	12,279,546.33	804.7	493,620.15	244,171.81	14.6	16,300,530.37	8,099,672.51	553.0	303,482.87	151,741.43	11.5	2,661,359.92	Illinois
Indiana	7,577,444.16	3,655,540.97	225.7	182,566.05	89,656.72	6.4	15,982,528.45	7,801,428.22	522.8	634,177.67	307,774.89	19.8	2,457,991.20	Indiana
Iowa	23,195,778.19	9,237,031.86	1682.9	98,400.80	43,700.00	2.6	8,578,488.76	3,982,957.08	620.3	384,200.75	187,242.39	43.6	1,885,205.67	Iowa
Kansas	17,084,136.48	6,043,176.80	502.7	2,781,749.75	992,516.99	73.9	14,802,618.63	5,843,068.89	575.6	2,132,084.04	913,632.51	105.9	1,506,893.81	Kansas
Kentucky	10,822,980.31	4,613,947.28	429.4				7,594,366.28	3,663,928.55	329.2	101,082.14	50,541.07	4.0	2,043,322.10	Kentucky
Louisiana	8,488,463.18	3,636,143.36	661.2	15,207.25	7,603.62		5,712,124.28	2,829,358.51	372.3				792,336.51	Louisiana
Maine	6,911,058.78	3,299,935.38	230.7	198,869.11	98,755.62	9.4	1,495,468.85	743,302.17	53.9	479,738.34	231,798.78	21.6	716,180.05	Maine
Maryland	6,760,044.42	3,213,321.78	243.2				2,260,474.84	928,085.95	72.2	648,061.15	250,366.54	18.4	257,175.73	Maryland
Massachusetts	10,191,202.02	4,105,727.22	232.8				5,264,835.09	1,832,245.47	92.5	813,848.46	213,917.12	11.8	1,767,890.19	Massachusetts
Michigan	13,434,135.07	6,060,612.23	494.5				13,928,561.23	6,708,729.87	494.7	45,171.00	22,585.50	1.4	3,087,844.40	Michigan
Minnesota	24,037,561.24	9,885,843.07	2292.0	108,570.20	39,500.00	12.2	9,227,309.72	4,265,429.97	746.6	1,140,925.17	565,100.00	185.0	562,545.96	Minnesota
Mississippi	7,888,193.89	3,828,941.39	655.0				7,706,383.19	3,845,261.10	489.8	485,474.59	242,537.28	10.3	1,614,533.23	Mississippi
Missouri	11,352,027.70	5,245,899.18	803.5				15,480,902.51	7,386,933.92	647.5	3,875,845.78	1,875,736.82	218.3	3,431,618.08	Missouri
Montana	8,867,279.16	4,384,335.12	791.4	8,089.35	8,089.35		2,964,984.63	2,189,910.66	281.8	1,079,275.33	612,493.90	119.2	3,771,587.97	Montana
Nebraska	7,876,337.16	3,714,691.59	1440.4	68,571.72	34,285.86	5.9	6,909,749.52	3,361,602.38	720.2	1,032,793.23	511,216.75	84.6	3,829,149.42	Nebraska
Nevada	3,460,245.52	1,853,624.98	225.6	365,472.06	318,584.01	15.6	4,464,114.49	3,733,529.62	378.5	67,255.43	56,088.90	3.5	928,493.49	Nevada
New Hampshire	3,076,750.19	1,487,867.58	171.3				981,701.45	461,970.62	33.2	375,706.04	175,700.27	10.8	309,425.53	New Hampshire
New Jersey	7,623,795.12	2,661,531.49	148.7	217,382.46	76,260.00	3.8	10,705,257.33	2,805,782.10	75.2	417,573.68	107,667.49	4.1	938,005.92	New Jersey
New Mexico	5,306,286.45	2,758,849.68	714.3				6,568,161.27	4,314,425.58	684.2	812,968.30	499,975.47	51.6	1,016,081.27	New Mexico
New York	18,862,742.49	8,257,844.44	572.7	284,086.13	99,430.84	9.4	24,941,766.96	9,693,252.97	569.1	7,684,000.00	2,455,653.75	152.3	6,201,966.00	New York
North Carolina	12,567,732.97	5,676,757.66	884.7				9,623,594.36	3,484,417.74	266.6	2,354,959.10	1,060,134.58	55.2	2,072,941.02	North Carolina
North Dakota	9,088,973.11	4,418,505.42	1587.9	86,740.75	43,370.37	16.0	3,370,976.83	1,660,123.46	539.8	381,776.20	190,888.07	60.2	2,050,768.68	North Dakota
Ohio	33,122,751.43	11,879,917.99	962.5	459,731.22	163,828.34	13.1	12,385,183.65	4,717,444.78	340.2	2,750,393.94	935,045.01	76.0	2,443,927.88	Ohio
Oklahoma	12,986,865.26	5,888,852.03	497.3	411,850.09	187,247.45	18.2	8,493,819.45	4,119,841.77	368.3	2,028,739.97	865,691.10	95.0	1,475,070.65	Oklahoma
Oregon	12,082,873.17	5,819,093.79	655.6	79,706.63	48,435.61	7.9	2,842,204.41	1,656,086.90	167.7	872,730.10	533,558.61	45.4	448,984.09	Oregon
Pennsylvania	36,825,248.98	14,114,694.79	729.7	197,191.55	73,986.25	4.6	19,620,814.18	5,637,487.50	335.0	4,813,903.07	1,298,345.00	85.3	3,477,102.46	Pennsylvania
Rhode Island	1,774,397.25	779,227.96	46.0	157,932.08	62,600.00	3.1	1,243,889.16	438,306.80	25.2				652,906.24	Rhode Island
South Carolina	9,016,476.73	4,124,045.22	924.4	240,520.39	117,589.88	50.8	5,955,771.01	2,344,763.35	464.3	819,748.19	233,683.58	61.9	867,463.97	South Carolina
South Dakota	8,674,597.86	4,244,636.27	989.8	103,810.58	51,905.28	12.4	7,237,802.57	3,670,982.83	1002.2	813,788.37	376,425.51	72.3	374,730.11	South Dakota
Tennessee	6,805,683.35	3,313,936.07	259.6	854,869.74	427,434.87	24.0	12,824,954.12	6,028,528.47	409.3	1,642,967.93	710,195.61	62.6	1,544,541.98	Tennessee
Texas	42,341,998.56	16,190,624.91	3122.8	726,947.57	346,567.70	66.3	25,249,202.33	9,984,108.01	1564.7	3,471,735.76	1,249,038.73	238.6	3,953,873.65	Texas
Utah	3,304,423.75	1,695,805.92	219.0	138,485.53	101,152.07	23.7	4,245,735.17	2,705,463.91	280.5	1,036,761.36	701,792.94	69.6	712,258.16	Utah
Vermont	1,922,114.16	942,769.12	74.4				1,527,160.47	731,432.50	42.6	392,931.82	194,701.40	7.9	665,076.98	Vermont
Virginia	10,035,301.48	4,801,782.43	562.5				9,133,669.60	4,206,638.29	310.6	1,688,147.75	562,716.86	67.7	1,021,815.42	Virginia
Washington	11,384,615.67	5,290,895.45	457.0				2,851,003.81	1,306,000.00	121.6	903,139.27	415,300.00	33.8	874,482.55	Washington
West Virginia	5,489,747.95	2,365,041.53	255.6	468,127.14	211,158.74	11.7	4,315,997.16	1,947,380.81	152.1	1,079,140.03	474,528.01	35.0	756,022.91	West Virginia
Wisconsin	18,753,903.15	7,441,033.57	1325.3	268,053.95	134,026.97	9.2	4,099,336.27	2,040,340.42	179.3	588,053.18	282,155.39	15.4	3,760,894.65	Wisconsin
Wyoming	6,127,625.61	3,078,098.70	687.6	24,882.06	16,078.54	0.9	4,464,441.26	2,718,270.41	341.8	131,821.27	69,820.00	1.4	805,083.35	Wyoming
HAWAII TOTALS	$ 649,655,391.27	$ 237,852,399.82	32452.9	$ 10,880,886.93	$ 4,970,594.54	522.5	$ 386,357,594.14	$ 175,271,775.88	18341.6	$ 56,282,794.56	$ 23,625,846.62	2541.6	$ 365,625.00 83,404,383.14	HAWAII TOTALS

* Includes projects reported completed (final vouchers not yet paid) totaling: Estimated cost 52,378,332.83 Federal aid 24,358,593.57 Miles 2,637.2

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS

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

REPORTS

Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.
Report of the Chief of the Bureau of Public Roads for 1920.
Report of the Chief of the Bureau of Public Roads for 1921.
*Report of the Chief of the Bureau of Public Roads for 1922. 5c.
*Report of the Chief of the Bureau of Public Roads for 1923. 5c.

DEPARTMENT BULLETINS

No. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
*136. Highway Bonds. 20c.
220. Road Models.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*314. Methods for the Examination of Bituminous Road Materials. 10c.
*347. Methods for the Determination of the Physical Properties of Road-Building Rock. 10c.
*370. The Results of Physical Tests of Road-Building Rock. 15c.
386. Public Road Mileage and Revenues in the Middle Atlantic States, 1914.
387. Public Road Mileage and Revenues in the Southern States, 1914.
388. Public Road Mileage and Revenues in the New England States, 1914.
*389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914. 15c.
390. Public Road Mileage in the United States, 1914. A Summary.
*393. Economic Surveys of County Highway Improvement. 35c.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
*463. Earth, Sand-Clay, and Gravel Roads. 15c.
*532. The Expansion and Contraction of Concrete and Concrete Roads. 10c.
*537. The Results of Physical Tests of Road-Building Rock in 1916, Including all Compression Tests. 5c.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
*583. Reports on Experimental Convict Road Camp, Fulton County, Ga. 25c.
*586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916. 10c.
*660. Highway Cost Keeping. 10c.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
*691. Typical Specifications for Bituminous Road Materials. 15c.
*704. Typical Specifications for Nonbituminous Road Materials. 5c.
*724. Drainage Methods and Foundations for County Roads. 20c.
No.*1077. Portland Cement Concrete Roads. 15c.
*1132. The Results of Physical Tests of Road-Building Rock from 1916 to 1921, Inclusive. 10c.
1216. Tentative Standard Methods of Sampling and Testing Highway Materials.

DEPARTMENT CIRCULAR

No. 94. TNT as a Blasting Explosive.

FARMERS' BULLETINS

No.*338. Macadam Roads. 5c.
*505. Benefits of Improved Roads. 5c.
*597. The Road Drag. 5c.

SEPARATE REPRINTS FROM THE YEARBOOK

No.*727. Design of Public Roads. 5c.
*739. Federal Aid to Highways, 1917. 5c.
*849. Roads. 5c.

OFFICE OF PUBLIC ROADS BULLETIN

No. *45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.

OFFICE OF THE SECRETARY CIRCULARS

No. 49. Motor Vehicle Registrations and Revenues, 1914.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
63. State Highway Mileage and Expenditures to January 1, 1916.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
161. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Highway Act and Amendments Thereto.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH

Vol. 5, No. 17, D– 2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D– 3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D– 4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D– 6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

---

*Department supply exhausted.