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FOREWORD

With the exception of the development of our public school system, there is perhaps no other constructive problem which so vitally affects our common life as the building and maintaining of a public road system. It is only within the last decade that our officials have begun to realize that the efficient building of public roads requires skill and training and experience in all its phases. War conditions are bringing about new problems in transportation, and the public road system is looked to for at least a partial solution of this vital question.

It is the purpose of this short bulletin to call the attention of our people to some of the problems connected with our road work in the hope that an awakened interest will insist upon a more intelligent and expert handling of this public enterprise. In addition to a brief summary regarding the Fifth Road Institute, this bulletin contains certain papers (some of them having been given as discussions at this Institute) which emphasize especially the urgent need of systems of highways; efficient organization of highway departments and road forces; correct road financing; effect of public road building upon our military problems; road maintenance, etc. These are problems which can be solved only through an awakened public opinion and a determined popular demand.

H. M. Berry, *Secretary,*
North Carolina Geological and Economic Survey.

The Road Institute

The Fifth Road Institute was held at the University of North Carolina, Chapel Hill, N. C., February 19 to 22, inclusive, and was undoubtedly the most successful institute of any of the series yet held. The *Greensboro News* of February 20 aptly described it as "the great intensive educational event of the week," and further said: "This short course, which has now become definitely established as a feature of the service of the University to the State, is jointly conducted by the State Highway Commission, the University, and the State Geological and Economic Survey, and is intended primarily for road engineers and road officials. It is unfortunate that it is not also largely attended by newspaper writers in all departments who have occasion to handle road problems and in whose hands is the publicity work that has been and must continue to be so great a part of the road-building impetus throughout the State."

At the First Institute, held in March, 1914, there were 24 counties represented with 54 men attending; at the Second Institute, 1915, there were 29 counties represented with 80 men attending; at the Third Institute, 1916, there were 127 men in attendance representing 43 counties; at the 1917 Institute, 132 registered from 41 counties; and at the Fifth Institute, 1918, there were 124 registered from 47 counties, as follows: Alamance, Anson, Alexander, Beaufort, Buncombe, Burke, Catawba, Chowan, Craven, Cumberland, Currituck, Davidson, Davie, Durham, Forsyth, Gaston, Gates, Granville, Guilford, Halifax, Haywood, Henderson, Iredell, Johnston, Lee, Macon, Mecklenburg, Montgomery, Moore, Nash, New Hanover, Northampton, Orange, Pasquotank, Person, Pitt, Randolph, Robeson, Rockingham, Rowan, Stanly, Vance, Wake, Warren, Watauga, Wayne and Wilkes.

Of the 1918 attendance, there were 30 road engineers, 44 county and road commissioners, 3 bridge engineers, 15 superintendents, 5 patrolmen, 3 supervisors, 1 foreman, 1 inspector, 1 trustee, 12 representatives of companies, and 10 visitors from the States of Georgia, Ohio, South Carolina, West Virginia, and District of Columbia.

The program was carried out practically in its entirety, and it seemed to be the consensus of opinion among the men attending that the practical lessons learned were of great value to them in their road work, and that the Institute is proving a most practical and beneficial factor in the road work of the State.

It was the object of those who have the Institute in charge to make this Institute a clearing house of knowledge gained in actual experience

by men who are doing the road work of the State and of the country. Also many problems brought about by war conditions were discussed in detail.

It was a matter of great regret that the Director, Colonel Joseph Hyde Pratt, could not have charge of the Institute; but in Col. Pratt's absence, these duties fell upon Mr. W. S. Fallis, State Highway Engineer.

Resolutions were passed by the Institute relating to the Bankhead Highway and the Moore Bill in Congress, as follows:

Whereas the Bankhead National Highway has been located east from Memphis to Birmingham, Atlanta, Charlotte, Salisbury, to Greensboro; and whereas two routes from Greensboro to Washington are proposed, the Western route via Danville and Lynchburg, and the Eastern route via Raleigh and Richmond. Therefore be it

Resolved, That we urge the adoption of the Eastern route, so as to protect the capitals of North Carolina and Virginia; so as to connect up the six cantonments in Virginia with those in the South and so as to connect Hampton Roads, our naval base, with the Capital of the Nation.

Resolved, That we urge our Senators and Representatives in Congress to support the Moore Bill for working interned German prisoners on the public roads of this country.

Military Roads

By Joseph Hyde Pratt, State Geologist
and
Lieutenant-Colonel of 105th Engineer Regiment

The critical situation that has existed in this country for the past year in connection with transportation has peculiarly emphasized the need for more concerted action and coöperation on the part of the several states in the construction of hard-surfaced interstate roads that can be used for transportation of commercial trucks over long distances; and, in time of war, be used in transporting troops and military supplies by motor trucks. It has also demonstrated very strikingly the need of the several states for taking more definite action and supervision in regard to the location of the main thoroughfares of their respective states.

With the rapid increase in the construction and utilization of motor trucks of various capacities and automobiles, and the fact that this character of vehicle is becoming a necessity in all walks of life and in all business, both in the country as well as in the city, it becomes absolutely necessary that State highway officials and county highway officials shall give heed to the need of constructing roads, both regarding location and surface, which will meet the demand of this type of vehicle. The rapidity with which the motor truck and the automobile travel over the public roads, and the necessity of their having a hard-surfaced road, increase very greatly the demand and the actual necessity that the roads that are to be built and reconstructed in any state shall first be those connecting commercial centers with each other and the several counties and with the adjoining states.

It will be found that approximately 80 per cent of the traffic of any state will be actually carried over approximately 20 per cent of the mileage of the roads of that state. When it is considered that the life of the road, its cost of maintenance, and the type of surfacing material required are dependent upon the kind of traffic that is going over the road, it will readily be realized that the 20 per cent of the roads of the State which are to carry the 80 per cent of the traffic will require a stronger and harder type of surfacing material, while the balance of the 80 per cent of the roads carrying only approximately 20 per cent of the traffic will not require as hard a surface, as these lighter types of surfaced roads can be maintained at a comparatively low cost.

The location of these 20 per cent mileage systems in each state can readily be worked out by any impartial board, and when constructed they will be found to be highways connecting the chief centers of each state and will join with the main highways of the adjoining states. In fact, they will become the highways over which the people of the State

will carry their commercial products; and, in case of necessity, they can fully as cheaply transport these same trucks long distances from commercial centers not only of their own State, but from adjoining states.

From a military standpoint, these roads at once become military roads of importance for transporting all kinds of supplies to military cantonments, and in fact can be used and will be used for transporting troops and supplies by motor vehicles not only from state to state, but over long distances from various parts of this country.

The Effect of the War on Road Building

By T. F. Hickerson
Associate Professor of Highway Engineering, University of North Carolina, and Member of the State Highway Commission.

Road building in many countries originated as a military necessity. History tells us that the Romans built roads on a more extensive scale than any of the other nations. What was the motive? It was clearly a military motive that caused road building to be a state policy in the Roman Empire. The Romans realized that roads were an absolute necessity in the conduct of war. The construction of their roads continued to such an extent that at the end of the year 200 B. C. the total system in the Roman Empire comprised about 48,500 miles traversing all of Europe and the northern part of Africa. Certain of the great military roads were 36 to 40 feet wide.

The French Road System

The French road system, which was considered the finest and most complete in the world, originated in the time of Napoleon, to help carry out his military expeditions. Practically all the highways of France were planned and constructed primarily for military purposes.

When the war started France had over 371,000 miles of roads, and it happens that these were almost exclusively of the waterbound macadam construction. The French road system is classified as (1) national roads, the trunk routes 60 feet wide with a macadam surface 24 feet in width; (2) departmental roads, those main routes 42 feet wide with macadam surface 18 feet in width; (3) secondary roads, including the county and country roads, 27 to 30 feet wide with macadam surfaces 9 to 12 feet in width.

The French road system has met the military situation well. The roads have saved France. The following technical features of the road design have proven of especial advantage: (1) easy grades, (2) splendid drainage systems, (3) good foundations, (4) good width, (5) high ratio of road mileage, (6) road signs, (7) easy maintenance.

Road Maintenance the Big Problem in France

The French road system is so complete that it has been unnecessary to build new routes except in a few places to avoid shell fire, this being accomplished by locating the road on the leeward side of the hill. The big problem has been to keep up and maintain the old roads under the tremendous traffic that must continuously go over them.

During the attack at Verdun one road 50 miles in length had to withstand a continuous procession of about 5,000 motor trucks every 24 hours. On the main feeders to the front four solid lines of vehicles move every day in almost continuous procession. Under traffic of such great intensity, the roads have worn very rapidly. It has been absolutely necessary to repair the roads at once in some makeshift fashion without interrupting traffic. The holes have been filled with broken stone or whatever material was available, and traffic packed it down. It is very interesting to note in this connection that the water-bound macadam, the prevailing type of road surface in France, lends itself extremely well to the demands of war. In none of the other types of modern pavements can repairs be made in such a simple manner under excessive traffic conditions. It is said that 1,000,000 men are now employed in maintaining the roads of France.

Recent Military Road Building in Italy

The absolute necessity of roads for military purposes was well illustrated in the Italian campaign against Austria. Near the frontier there were very few roads and these were quite narrow. It is reported that the Italians had to build 4,000 miles of road in order to keep their armies supplied with food and ammunition.

England's Experience

Road improvement in England and Wales is now being carried on more extensively than ever before—not in spite of, but because of, the war. The heavy traffic under the stress of war preparations has demanded thicker foundations and better surfaces.

Effect of the War on Road Building in the United States

If we profit by the experience of other nations, then this war can have none other than a stimulating effect on road building in the United States. More attention is going to be paid to the planning of a road system that will serve military as well as commercial purposes. It is true that every road over which food and supplies can be transported readily is of military importance, but there are in addition certain roads which should be built strictly for military purposes regardless of whether they would be warranted on the basis of commercial needs alone. A number of such routes have been suggested by military authorities. Among these might be mentioned the roads connecting camps or leading to forts or other points of military importance; a road along the eastern coast (one along the western coast is already built), along the Mexican border and numerous radial roads connecting places of supply with selected points of defense.

The requirements of a military road do not differ materially from those of a modern commercial highway. The heaviest ordnance load weighs no more than the largest present-day commercial truck. The requisites for the wearing surface of a military road are as follows: (1) absolute dependence in all kinds of weather, in all seasons of the year, under the most severe usage; (2) wear resistant, so that extensive or frequent repairs will not be necessary; (3) easy and quick to repair without interrupting traffic and with simple tools and materials; (4) low in tractive resistance, and (5) offering a good foodhold for horses and a good grip for rubber tires, and at the same time smooth enough to allow a good rate of speed for motor trucks.

The Government's Position on Road Building in 1918

The policy which the Department of Agriculture recommends and urges for the road building program during the year 1918 is as follows: The maintenance of the roads already constructed; the construction and completion of those highways which are vitally important because of their bearing upon the war situation or for the movement of commodities; the postponement of all road construction relatively less essential or not based upon important military or economic needs.

We are obliged to conclude that the Government wishes to encourage rather than retard road building in general during the war, because practically every road that is contemplated will fall in the first two groups mentioned—that is, it will be based upon important economic or military needs. If we classify our roads as (1) commercial, (2) military, (3) tourist, only the last class could be considered for postponement according to the policy of the Department of Agriculture.

The writer believes that we cannot carry out completely our scheme of preparedness unless large appropriations are made by the Government for a system of national highways planned in coöperation with the War Department to serve primarily military needs in case of war and economic needs in times of peace.

Influence of the War Upon Bridge Design

By Colonel J. N. Ambler
Consulting Bridge Engineer

An ancient story tells us that when Cato was asked what he considered the most important study in agriculture, the old Roman answered, "Cattle." When asked what he considered of second importance, again his reply was "More cattle." And when his interlocutor inquired what he considered of third importance, his reply, was "Still more cattle."

Would to God that the suggestions of this grand old man in furtherance of the peaceful pursuits of agriculture today had first place in the nation's needs.

The cry today is for steel, for more steel, and for yet more steel! The demand for steel in the construction of ships, of cannon, of small arms, and of munitions is past belief.

Old stocks on hand have been exhausted and the mills making steel have been so overwhelmed with orders from foreign countries at first, and now from our own Government as well, that it has been found necessary to commandeer, wholly or in part, the steel mills and structural shops of the country.

Some of these plants which have built bridges exclusively are now devoting their attention largely to the construction of submarines and other types of sea-going vessels.

The effect of all this has been to enormously increase the cost of steel, to render shipments tardy and uncertain, and to greatly cripple the business of building steel bridges.

The demand for timber for use in building the thirty-two military cities, for building wooden ships, wharves, docks, and terminals, as well as for housing labor, has emphasized the already growing scarcity of timber and increased its cost, though locally it may often still be had at reasonable cost.

The demand for cement has not kept pace with that for steel and timber, but concrete work has nevertheless increased in cost about 50 per cent. Other items which have conspired to increase the cost of bridges are labor, coal, and transportation.

The man-power of the country being moblized for war, whether for service on the battle-fields of Europe, upon the high seas, or in the machine shops and harvest fields at home, has greatly increased the cost of labor left available for other pursuits, as well as diminished its efficiency.

The gross mismanagement of the coal mining industry and the collapse of the railroad system of the country under the increased strain it had to bear have largely contributed toward increasing the cost of bridges.

The general effect of increased cost of labor, of food, of materials of construction, and of every imaginable commodity, has amounted to a general reduction of the buying power of the dollar until now a dollar is worth only about one-third of what it was worth when the European war began.

If, however, every person could get three times as much for his labor, or whatever else he had to sell, and there was sufficient currency in the country to meet these demands, things would still be normal. Unfortunately, it takes a considerable time for affairs to become so adjusted as to bring about this condition, and in the meantime there is great irregularity in the action of this diminished dollar, working great hardship in many lines of effort.

Such profound changes in the financial and economic conditions of the country cannot fail to react upon any given industry. Bridge building has not escaped, and the effect of these changed conditions and changed prices has been to destroy the relations which formerly existed between the most common types of bridges, viz: those of steel, of concrete, and of timber.

It now becomes profitable, therefore, to open up anew these questions and determine what these relations which seemed to be fixed before the war began have become under the influence of the changes already pointed out.

The most ancient highway bridges were of stone or of timber. Stone has long been given up for building arch bridges and within the memory of the writer has almost disappeared as a material for the piers and abutments, so no further allusion will be made to it. Over the greater part of last century timber bridges were largely used. There were beam bridges for spans up to 40 feet and trussed bridges usually of the Howe or Town's Lattice type up to spans of as much as 230 feet.

The shorter trussed bridges, of the lengths known as pony spans, were seldom covered from the weather, and having deficient sway, bracing soon became loose and unsafe.

On the other hand, the longer bridges, where the trusses were sufficiently high to admit of overhead bracing, would last about as long as a steel bridge with such care as is usually given to the latter. Very few people at the present time seem to realize the possibilities of the timber bridge and its long life, if properly cared for.

A few years ago, while swimming in the Susquehanna River in Pennsylvania, an old bridge of this type was pointed out to the speaker, which had been built long before the Civil War. The inhabitants tried

to burn it when the city of Harrisburg was menaced by Stuart's calvary in the Gettysburg campaign, but did not succeed, and for aught I know it is still there.

Not so many years ago there were wooden railroad bridges across the James River at Lynchburg and at Richmond, Va., and across the Potomac at Washington.

Several years ago the writer saw a covered wooden bridge of 210-foot span removed from its site at Elkin, N. C. With the exception of a decayed lower chord, which could have been easily replaced, the bridge was in most excellent condition after some forty years of service. This bridge was of the Town's Lattice type with a ribbed arch supporting each truss.

At North Wilkesboro, N. C., there is an old wooden bridge of the Howe truss style which spans Reddies River. This bridge did service as a railroad bridge for some years until taken down and removed to its present site. The flood of July, 1916, removed this bridge and wallowed it over and over down the river for about three miles. When located and examined it was found to be almost unhurt, was taken to pieces, brought back and set up on the original piers, none the worse for its remarkable adventure.

During the past year the speaker was retained to design and construct two wooden bridges at Occanneechi Island, Virginia. One of these bridges had a span of 68 feet and I selected the Howe truss, pony style, laying myself out to try and meet the difficulties of this form of bridge as to rigidity, sway bracing, and protection. Timber was obtained locally, the head and foot castings were designed in detail and made in the foundaries at Winston-Salem, where also the tension rods were made, upset, and threaded. The castings were designed so as not to hold moisture and all points of contact of timber and iron, or timber and timber, were covered with a heavy coating of tar. After the timber had seasoned the bridge was well painted. This bridge was built at very much less expense than a steel bridge, and has proven entirely satisfactory for the purpose for which it was intended.

Of all styles of wooden bridges which have come under my observation, the Howe Truss is believed to be the most economical of material and certain in its results. As its stresses can be definitely computed, it is susceptible of intelligent design, and can be adapted to the heaviest concentrated loads of modern motor trucks. In this respect it has an immense advantage over the Town's Lattice, with or without the supporting arch ribs, since this type is incapable of mathematical analysis, the designer can have no certain knowledge of the action of its stresses, and hence a bridge of this character becomes dangerous when subjected to the searching effect of heavy concentrated loads.

Under old-time conditions, when the heaviest load to be carried was a four-horse team with a cord of wood, the above consideration was immaterial.

As the forests were cut away and good timber became scarce and more expensive, the steel bridge gradually superseded the timber bridge, until at the outbreak of the war it had full sway, and except in outlying country districts where timber was still abundant, but few new timber bridges were being built. I have long been of the opinion that such overwhelming popularity of the steel bridge could not be justified, under all conditions, on any rational basis.

The past generation was certainly a time of expansion for the steel bridge. The accuracy of its design and construction, its trim appearance, and a common belief that it would last forever, coupled with the decreasing cost of structural steel, all conspired to place this style of bridge upon a pedestal in the public mind. And when the open-hearth Bessemer process of steel manufacture was perfected the reduction in cost assured its permanent success. I would not be misunderstood as saying one word derogatory of the steel bridge, as it is certainly the most desirable style of bridge under most conditions that prevailed up to the beginning of the war. However, the high cost of materials now has opened up this question afresh and made it profitable to consider other types in relation to the steel bridge, which had certainly become the standard of bridge building for highway purposes.

To most human minds the idea of change, of something new, is delicious, and just as there are changes in fashion affecting the dress of women, so even staid and sober business men feel this subtle influence and are not indifferent to the call of the new, even in so prosaic a matter as bridge design.

So it happened that when the experiments of Thacher, Melan, Ransomme, Emperger, and others made reinforced concrete a practical working reality, the public mind at once leaped to the conclusion that here was a cure for all past troubles. It was pointed out that the concrete bridge with its massive lines and great strength, and its architectural beauty, would forever force the steel bridge to assume an inconspicuous position. Some leading engineers seem to have been carried completely off their feet by these pretensions.

Let us make a cold-blooded analysis of the relation which really existed between the concrete bridge and the steel bridge before the war had upset this and almost every other relation.

Abstract considerations can often be illustrated best by a real case which involves their principles.

The city of Rome, Georgia, is situated in the fork of two rivers. The Etowah and Oustanaula rivers unite here to make the Coosa River. All these are navigable. The city had two old steel bridges spanning the Etowah, and one on the Oustanaula. The first two were a single span, each of about 325 feet, covering the entire river without obstructing piers. The last had a swing span in the middle of the river to admit of vessels passing the bridge.

Since these bridges had been built many years ago, they were not designed for the heaviest street cars in present use, nor were their floors wide enough for the streets which they carried. It was decided to replace them with bridges having a roadway 50 feet wide with two sidewalks and capable of carrying a 30-ton street car. The speaker was among a number of bridge engineers who were invited to examine this situation and submit propositions on the design and supervision of construction.

Among the first things discovered after my arrival was that a city ordinance made it mandatory that these bridges be built of concrete. Certain financial interests, fearing that a city ordinance would not be strong enough, had gotten this ordinance backed by an act of the Georgia Legislature, so that the bridges *must be* concrete. A study of the conditions surrounding all these bridges convinced me that this would be highly unwise. When the commissioners met at the courthouse I decided not to submit any proposition on concrete bridges, for the following reasons:

1. The three steel bridges could be built for about $125,000, whereas, if built of concrete, the cost would be $250,000, or double.

2. I did not see any correct business in tying up $2 at this time when $1 would answer, to provide against a condition say 500 years from now. It is the history of practically all steel bridges that after serving for about one generation they are replaced by new bridges adapted to the traffic conditions which prevail at that time.

3. Steel bridges do not require such unimpeachable foundations for their piers as do concrete bridges. A pier settling an inch or two might not do any serious damage to a steel bridge, whereas it would spell ruin for a concrete one. Since the foundations on the Oustanaula looked treacherous to me, this question became of prime importance.

4. Since it was not financially practicable to build single-span concrete bridges 325 feet long over the Etowah River, it would become necessary to put two piers into the river, dividing the bridge into three spans. Already, when these two rivers are flooding, canoes can be run through the main business streets where the water has backed up into the banks and retail houses. If now these rivers were obstructed with piers and arches and their waterways reduced possibly one-third, the effect would be disastrous to the city as in similar cases of cities on the Sciota and Wabash rivers.

Leaving this case with its lesson and going back to general conditions as between steel and concrete bridges, we may note the following:

Under pre-war conditions the concrete bridge would cost ordinarily from 50 to 100 per cent more than the steel bridge on concrete piers. It requires much more rigid foundations and is much more liable to injury from defective foundations than a steel bridge. It requires more exacting inspection during construction—a thing which many counties seem

unwilling to give. The difference in cost can hardly be justified on business grounds. While capable of architectural treatment in a higher degree than a steel bridge, yet the concrete bridge rarely ever gets it, and as usually constructed is a model of ugliness and clumsiness. With these considerations before us, I should say that under pre-war conditions a concrete bridge was justifiable:

1. For some large monumental bridge for a city where a high degree of architectural treatment could be assured.

2. For ornamental grounds, parks, etc.

3. For highway bridges subjected to heavy traffic on important roads leading out from cities.

4. For short highway bridges generally, where the county officials neglect to keep steel bridges painted and floors repaired.

Coming now to the present, with its vastly changed conditions, structural steel having advanced three prices, while concrete is only about 50 per cent higher than normal, coupled with the fact that steel is almost impossible to get in any reasonable length of time, the dictates of sound engineering business would seem to be as follows:

1. In each case get comparative estimates between cost of steel and a concrete bridge, with full consideration of assurances as to delivery of material. The concrete bridge will often be found to be much cheaper now.

2. In cases where good timber can be had at reasonable cost, it would be wise to consider the old type of Howe truss covered wooden bridge. In many cases rubble-stone masonry will be found cheaper than concrete for piers and abutments under present conditions.

A general view of the entire situation leads to the conclusion that bridge building has been greatly hindered by the present conflict, and probably will not be resumed in full measure again until its close.

Another reflection leads to the belief that there is a new era for bridge building ahead of us after the war.

In this era bridges will be designed for the greatly increased loads of auto-trucks, possibly for concentrated loads of 30 tons including the truck and trailers. Upon Government roads of military importance it is likely that the bridges will be designed for the passage of batteries of heavy field artillery as well, in order that the bridges may take efficient stand, as posts of the roads, which they are, in order that the roads may take their proper position in that great military preparedness which will at once insure peace as well as the fruits thereof.

The Nation's Road Building Program

Combined forces of the Government, states, and counties will spend for highway improvement in 1918 the amazing total of $263,096,610. This is the announcement contained in the first detailed survey of the nation's road building plan issued by officials of the touring bureau of the B. F. Goodrich Rubber Company, who have been in contact daily for two months with highway commissioners of the states.

While this sum seems staggering, eclipsing by 82 per cent the expenditures of any previous year and in money figures that of 1917 by $118,797,750, road officials of the Government and states said it represented merely a "drop in the bucket" of what should be spent before the war was concluded. They admit the railroad situation has made imperative lavish road appropriations—the total of this year is little better than half what Secretary McAdoo has announced as necessary for the upbuilding of the overtaxed American railroad system. Calculations by Government officials are that with good highways, motor trucks and motor vehicles are capable of carrying approximately 200 per cent more freight than the railroads. In these same calculations they estimate the value of our highways at $6,240,000,000.

Data supplied the Goodrich touring officials discloses that the productive possibilities of communities were considered above all else in determining the sums to be allotted for road improvement. Thus we notice that the South and Middle West appropriations exceed those of other regions by many millions. Texas, for instance, leads all others with contemplated highway development, announcing the amazing assignment of $25,000,000 for road improvement. Last year it spent $5,000,000.

A remarkable feature of this year's national program is the overshadowing of the automobile industry by the highway building industry. It is admitted that 1917 was the banner year in automobile production. And yet this year's figures on road improvement transcended the increased automobile production of last year by 25 per cent.

Here are the amounts to be spent this year by states, compared with those of last year:

	1917	1918
Alabama	$ 150,000	$ 2,500,000
Arizona	750,000	3,000,000
Arkansas	4,000,000	12,299,000
California	3,210,000	12,000,000
Colorado	3,100,000	3,635,000
Connecticut	2,500,000	2,500,000
Deleware	320,000	1,000,000
Florida	2,000,000	2,750,000
Georgia	3,500,000	4,300,000
Idaho	800,000	800,000
Illinois	5,500,000	17,000,000
Indiana	6,000,000	17,380,000
Iowa	15,140,000	15,500,000
Kansas	6,500,000	10,500,000
Kentucky	4,500,000	4,500,000
Louisiana	8,000,000	5,300,000
Maine	400,000	1,150,000
Maryland	2,250,000	2,700,000
Massachusetts	4,500,000	3,083,000
Michigan	1,500,000	2,300,000
Minnesota	3,884,925	7,700,000
Mississippi	1,500,000	3,500,000
Missouri	2,500,000	3,000,000
Montana	2,000,000	3,000,000
Nebraska	3,500,000	1,279,757
Nevada	300,000	560,000
New Hampshire	1,038,704	587,000
New Jersey	4,500,000	8,100,000
New Mexico	500,000	1,500,000
New York	7,000,000	10,000,000
North Carolina	1,750,000	2,500,000
North Dakota	1,000,000	3,500,000
Ohio	2,829,858	6,000,000
Oklahoma	3,500,000	6,400,000
Oregon	1,371,226	5,653,516
Pennsylvania	3,250,000	5,750,000
Rhode Island	481,724	600,000
South Carolina	1,173,000	1,498,000
South Dakota	350,000	1,500,000
Tennessee	2,000,000	3,000,000
Texas	5,000,000	25,000,000
Utah	943,129	1,131,754
Vermont	485,000	685,000
Virginia	2,332,577	2,155,000
Washington	3,500,000	8,408,250
West Virginia	8,000,000	14,000,000
Wisconsin	4,588,717	10,125,000
Wyoming	400,000	806,000
Totals	$144,298,860	$263,096,610

Roughly, Goodrich officials estimate that the expenditures for highway improvement is approximately $2.35 per capita; or, to italicize this, each man, woman, and child in the nation would contribute this

much for the building and bettering of roads for the movement of supplies were taxation on such a basis. Were the expense apportioned out on an average basis, each state would pay $5,400,000.

Necessity for vast improvement of road conditions is emphasized in reports from the South, where unprecedented truck travel is reported. Loads exceeding for size all expectation are reported rumbling over highways, and the State Highway Commission of Maryland points out that the millions that have been invested must be spent in vain unless states undertake to repair as quickly as they build. "It is a common sight," reports the Maryland commission, "to see loads rumbling over our highways now that would ordinarily wreck a city street. Our whole road fabric must be rent through if we continue to build and not to repair."

The only fly in the ointment is the labor problem. Several highway commissioners display marked uneasiness over the shortage of labor and freight cars for hauling road-building material. They expect Government aid.

Road funds include building and improvement of bridges, etc., but it is impossible to get an estimate on how much this phase will eat into the total. A tendency is manifest everywhere, though, to do away with the narrow road and construct only broad, firm-bodied roads capable of heavy traffic.

Reports from State Highway Commissioners to the Goodrich officials disclose some interesting individual features.

In Oregon, for instance, the Government and State bodies are spending five times what they did last year in order to build trunk roads into large timber tracts. From these is being taken the woods for the armada of ships Uncle Sam is constructing. In many cases roads have been planked by army engineers to enable the heavy trucks laden with mighty timbers to pass.

A. C. McKibbin, of the Missouri State Highway Board, writes that in forwarding to Washington reports on traffic areas in Missouri he gave first consideration to live stock, grain, poultry, mineral and timber producing areas. Into these, he recommended, auxiliary and tributary roads should extend.

Iowa is entitled to the palm for consistent road construction. This State, with more automobiles in proportion to its total population, spent $15,000,000 last year, and is doing the same thing this year. Approximately 6,000 miles of highways in the State are being improved and extended.

Recognition of the tremendous importance gasoline is playing in the war and in the sustenance of our automobile industry here is reflected in the figures from Oklahoma. Tulsa County, in the heart of the oil fields, is spending $1,750,000, which is more than some states spent dur-

ing the entire twelve months of last year. Another county, Okmulgee, is putting $800,000 into 43 miles of roadway.

Wisconsin is putting into effect a trunk system of roads which taps every community of the State. Officials of the Goodrich touring bureau consider the plan outlined by the Wisconsin commissioners one for others to pattern after. Much individual credit is due A. R. Hirst, one of the foremost civil engineers, for the installation of the road system.

Arkansas, which last year spent $4,000,000, is investing $12,000,000 in constructing a series of highways between Louisiana and Arkansas, via Hot Springs and Little Rock.

Illinois and Indiana rank next to Texas in expenditures for road building. Indiana has inherited 175 miles of the New Market highway and is also eager to polish up its share of the Dixie Highway.

Texas' huge appropriation is not inflated by any large Government tender. Federal authorities have given the Lone Star State just $875,000, and the counties and State have gone out and got the rest.

"In addition," writes a highway correspondent, "there are 230,000 automobiles to be registered in the State this year at an average registration fee of $8.32. Of this amount 50 per cent will be returned to each county to be used in highway maintenance. The other 50 per cent is retained by the State, and after all operating expense is paid the balance, if any, will go into the State fund for roads and highways.

Ohio, Pennsylvania, and Michigan, which play a large part in any highway program, owing to the fact that all Government truck caravans traverse their confines, are concentrating on those lanes used most by the big industries. Traffic between the huge rubber and steel cities of Ohio and Pennsylvania and shipping points will be uninterrupted in winter as well as summer. Plows are being purchased to keep open roads during winter months.

No startling increases in appropriations are reported from the east and New England states because highway commissioners there have never within the past decade allowed anything to interfere with a consistent road-building program.

Road Financing

The first problem in connection with road building, of course, and one in which the public has a determining interest, is securing the funds with which to carry on the work. There are two ways in which funds are raised for public uses: one is by direct taxation and the other is by borrowing the money. The chief advantage of the cash tax system is that no interest charges have to be paid by the present or future generations. There are, unfortunately, many undeveloped communities in which it becomes advisable to borrow the money for road building in the same way that farmers borrow the money to buy farms. If some farmers had to wait until they had the money to purchase their farms, they would probably never be landowners. Unless a community is able to raise by cash taxation enough money to finance the building of its main market roads within a reasonable length of time, the benefits resulting from the improvements are likely to be piece-meal. On the other hand, if a sufficient amount of money is raised either by direct tax or by a bond issue, resulting benefits are immediate and certain, provided that the money is spent wisely and under competent supervision.

If the community decides to go into debt for good roads, it should determine in advance what kind of bonds are to be issued, whether for long or short term, whether sinking-fund or serial bonds. The people of the community will do well to consider the advantage of short-term bonds for temporary improvements, and long-term bonds for work which is more or less permanent, and the advantage of serial bonds over sinking-fund bonds.

Before a community invests its money in a system of roads it should consider the traffic area of the road or roads to be improved; the present and future traffic in ton miles per annum, the estimated cost of hauling per ton mile at present, and what it will probably be reduced to by the improvement; the roads to be improved; the approximate cost of the improvement as borne out by surveys and estimates made by a competent engineer; the probable effect of the improvement on farm values, school consolidation and attendance, community betterment and the rural delivery of the mails; and whether the work can be carried on by direct taxation or whether it is desirable to resort to credit.

A comprehensive study of these facts will enable a community to determine whether it can afford to invest its money in good roads, how much it can invest profitably, how many miles of road it should build, what type of roads it would be most economical to construct, which road

should be improved first, and whether it would be wise to proceed under a cash basis or whether it would be best to issue bonds.

If the people decide it would be wise to issue bonds and distribute the burden over a period of years, then they should determine with careful forethought what kind of bonds should be issued, whether long-term or short-term, whether sinking-fund, annuity, or serial bonds, and what taxes should be imposed in order to extinguish the debt.

We would refer any one interested in this phase of road work to an article in *Southern Good Roads* for October, 1917, on "Road Building Serial Bonds for Money," by M. O. Eldridge of the United States Office of Public Roads. In this article Mr. Eldridge discusses most clearly and accurately the advantages and disadvantages of the various types of bonds.

Systems of Highways and Systematic Organization of Road Forces

To meet the present-day traffic requirements due in large measure to war conditions, it is absolutely necessary to work out a definite program which will give to the Nation, the States, and the counties a *system* of public roads, something as follows:

(1) *A System of National Highways built and maintained by the Federal Government.* Such highways should be surfaced with the best and most enduring type of pavement to be had, as they would carry the heaviest traffic of which a road is capable. The necessity for such highways is emphasized most at the present time because of the tremendous transportation problems we are now having to face. This is not a passing problem, but a growing one; for, no matter how soon peace may come nor yet how long delayed, the demands upon our transportation systems will not be lessened. It is not feasible to build more railroads to parallel the present lines in most instances. There is only one real and immediate solution of this problem, and that is the building of good highways over which motor-truck trains can be handled. Had the Atlantic States been belted with one great permanent highway over which thousands of trucks already available might have passed with loads of freight, the traffic tie-up might have been obviated. The military preparation of the United States would already be much further advanced through such a system of national highways.

(2) *A System of State Highways to be built and maintained by the State.* These highways should be given a durable and easily maintained surface, particularly within a radius of 10 to 20 miles of the towns and cities.

(3) Leading into these State Highways should be *systems of county highways,* built and maintained by the county under State supervision. These county highways should have such portions of them as are in the vicinity of large towns or cities, or where the traffic is heavy, surfaced with a durable pavement.

(4) *Each Township should have its system of roads leading into the County and State Highways.* In most cases the township roads should be surfaced with sand-clay or topsoil, when these materials are available, as they will undoubtedly meet all of the traffic requirements of these roads.

(5) Finally, the neighborhoods or precincts should have their dirt roads which, if kept properly dragged and maintained, would undoubtedly stand up under the light traffic of a small community.

To carry out such an ambitious program will require organization of officials along lines which have been worked out by experts as the most economical and efficient. We have such a national organization in the Office of Public Roads at Washington, which is prepared to help the states in their many road problems, and which handles the Federal Aid fund authorized by Congress in 1915.

We have in North Carolina a State Highway Commission prepared to assist the counties in their construction and maintenance problems.

In each county there should be a road commission, nonpolitical, composed of public-spirited business men, who will work in unison with the State and Federal authorities. In effecting our organizations, the State should furnish and have supervision of all engineers. This would be more economical, as one engineer could cover several counties; a better type of engineer would be insured; and his work would not be subject to the whims of local politicians, which has played such a disastrous part in our road locations of the past.

In the county, there should be a road superintendent responsible to the county board and to the State engineer in charge of that county. This superintendent should have supervision of the construction and maintenance forces of the county and township roads. He should have foremen or supervisors in each township and these in turn should have patrolmen responsible for the upkeep or maintenance of certain sections of road.

There are, of course, a great many details in organization which cannot be included in this general sketch, such as construction forces, maintenance forces, convict gangs, etc. The main idea we wish to convey, however, is the necessity for *systematic* work under *definite organization*, each member of the organization having his superior to whom he is responsible, and his own duties clearly defined.

County Road Organization

By C. R. Thomas
Associate Professor of Civil Engineering,
North Carolina State College of Agriculture and Engineering

The type of organization used for constructing and maintaining roads in the various counties of the State varies with:

(1) The amount of road funds available,

(2) The size and density of population of the county,

(3) The enterprise and progressive spirit of the citizens.

The amount of money available yearly from taxes varies widely; some of the poorer counties have as little as $2,000 a year, and a few counties containing large cities have as much as $100,000 a year; but the average county probably has from $15,000 to $30,000 a year. This fund may be used for both construction and maintenance purposes, but generally it is nearly all used for maintenance.

A sharp distinction should be made between construction and maintenance. Construction means the building of a new road or making a road better than it was before, just as the construction of a house means the erection of a building where none existed or the improvement of an old building. Maintenance means keeping the road in the condition it was just after it was completed, with due allowance, of course, for the effects of age and wear.

The size and density of population of a county very largely determine the total mileage of roads and the character of the wearing surface, whether earth, topsoil, gravel, concrete, etc. It is quite evident that a thickly populated county, or a county containing a large city, will have more travel on its roads, and stronger roads will be required. Large and thinly populated counties are frequently at a great disadvantage in building and maintaining roads on account of the large road mileage per capita within the county. Such a county would have a very different organization from a county thickly populated with the roads highly improved.

The enterprise and progressive spirit of the citizens has much to do with the type of roads and the organization to build and care for the highways. Some counties are not willing to put up with the type of roads with which other counties are satisfied. As a rule, a county with good schools and contented citizens has good roads, or is getting them rapidly.

Outline 1 shows the type of organization employed in many counties. The county board of commissioners has general charge of the county affairs, including the road and bridge work. They employ a superintendent or county engineer who has immediate charge of the work. He employs such assistants and gangs of workmen as may be needed. In some counties the convicts are also employed on the roads.

If a county has issued bonds for road building and has a large sum of money available at one time, the construction force would be very large until the roads were completed. Such work may be done by contracts or by forces hired by the county engineer.

Accounting for the money expended is a feature of road work much neglected at the present time in North Carolina. There are two kinds of accounting:

(1) Bookkeeping, or having a bill and receipt for all the money spent; and

(2) Cost-keeping, or showing how much was accomplished with the money spent.

Bookkeeping must be exact to the last cent, so that the records may show that all the money is honestly accounted for; but cost-keeping is for general information, used to facilitate economical work; and so cost records may be kept—only as exact as the occasion demands.

In Outline 2 is shown a diagram for a simple system of bookkeeping and cost-keeping.

OUTLINE 1

Diagram showing the organization for road construction and maintenance in a typical county.

- County Engineer or Superintendent
  - Construction
    1. *Hired labor crews.* Employed in grading, hauling material, building culverts and bridges, placing material, etc.
    2. *Contractors.* Employed in any of the work for which the county may use its own hired forces.
    3. *Convict crews.* Employed generally on work where the men can be kept together.
  - Maintenance
    1. *Road machine crews.* Employed in scraping the road to keep them smooth, cleaning ditches, etc.
    2. *Truck crews.* Employed in hauling materials, filling holes in the roads, etc.
    3. *Road dragging crews.* Employed in dragging the roads after rains.
    4. *Free labor crews.* Employed in caring for the less important roads.

OUTLINE 2

Combined voucher and cost systems for a typical county.

Voucher books on which are listed.....
1. Construction pay rolls
2. Maintenance pay rolls
3. Material bills
4. General expense bills

Construction costs .....
1. Road No. 1
2. Road No. 2, etc.
3. Bridge No. 1, etc.
4. Village No. 1, etc.

Maintenance costs
- Main roads (10-20% of total mileage)
  1. Road No. 1
  2. Road No. 2, etc.
  3. Village No. 1, etc.
- Secondary roads (80-90% of total mileage)
  1. Township No. 1
  2. Township No. 2
  3. Township No. 3, etc.

NOTE—The cost accounts are based on foremen's reports of labor and material used and checked by pay rolls and material bills. A separate account is kept for each road, bridge, village, or township by simply filing the daily reports under separate heads and summarizing the reports at convenient intervals.

Road Maintenance

Of the many problems confronting the road builder, there is none more important or more pressing than that of maintenance or upkeep of the roads after they are built. Maintenance should begin as soon as construction is completed, and kept up unremittingly.

The details of maintenance are as numerous as the types of surfacing materials used, and cannot be entered into here. As a general proposition, however, the public should demand of its officials that in deciding upon a surfacing material to be used on a proposed highway, they should constantly bear in mind the relationship of the traffic which that road is to carry and the cost of maintenance due to such traffic to the cost of the surfacing of the road. If traffic demands it, it is much more economical to use an expensive type of pavement, such as concrete, than a cheaper form of pavement which would require a very high maintenance cost.

The type of maintenance which is of especial interest to the people of North Carolina is the proper upkeep of our sand-clay, topsoil, and dirt roads. Below is given a brief outline as to this form of maintenance, which should be carried on under what is known as the patrol system.

Sand-Clay or Topsoil Roads*

The maintenance of the sand-clay and topsoil road consists in doing what is necessary to keep the surface smooth and hard; and the greater the amount of traffic over the road, the more continuous and costly will be this maintenance. The road must not be permitted to be cut into ruts or have holes developed. The best machine for maintaining this type of road is the road drag, and this can be used to advantage only when the road is wet. It should be used *after every heavy rain* if the road surface shows any tendency at all to develop even incipient ruts. The drag should go over the road before it dries out, to smooth and smear over the surface. The principle is not to bring any quantity of material from one part of the road to another, but it is to smear back into place and mash down while it is wet or moist the road surfacing material that has been displaced by traffic. If the road has become rutted and filled with holes, these should be filled up either by a road machine or by scrapes or by shovels, and then, after the first rain, the road should be thoroughly dragged again. As the principle of the sand-clay road is one of cementing and setting of the bonding material, the main thing is to have this bonding material wet before it can cement. It is similar in principle to mixing cement with sand in con-

*Taken from article by Joseph Hyde Pratt, *Southern Good Roads*, June, 1917.

crete. There is no advantage in rolling the cement after it has been put down. It does not become hard until it dries out and the bonding material sets. This is also true of sand-clay and topsoil roads, where the clay is the cementing or bonding material.

In maintaining a sand-clay or topsoil road, no material should ever be dragged from the ditches onto the surfaced portions of the road. All such scrapings as these usually contain more or less organic matter which will cause the road to disintegrate and finally destroy it. After the ditches have been brought into the right grade they should be disturbed just as little as possible. The grass should be permitted to grow from the ditches to the surfaced portion of the road, whenever it is possible, and one of the expenses of maintenance should be the keeping of this grass mowed. Before any material is needed to repair these roads provision should be made to obtain such suitable material to be added to a sand-clay or topsoil road in filling up any depressions or holes that may have formed, and holes which are too large to be remedied by the use of the road drag, and in replacing material that has been worn out or blown away. Care should be taken that the material used for this purpose is of the same character and quality as the original topsoil or sand-clay mixture. If necessary, such materials should be purchased ahead of time at various points along the road, so that the road supervisor will know where he can obtain suitable material with which to make his repairs. In adding this material to a sand-clay surface, the sand and clay, which should be of approximately the same character as the original surface, should be thoroughly mixed together and tamped into the holes and then the surface dragged. If the road drag has been used systematically and consistently on the road from the time it was built, it will be found that it is only very rarely that holes develop which have to be filled in this way. When it does become necessary, however, to fill ruts and holes with sand-clay or topsoil mixtures, or to add these materials to the surface of the road, it is absolutely necessary that the holes be thoroughly cleaned of all dead material and the bottom material loosened before any new material is added. It is of great importance also that the surface of the road be swept clean of loose, dead material and harrowed with a spiked-tooth harrow before the layer of the new material is added. If this is not done the new material will not become firmly attached and incorporated with the old material.

It is very necessary to have some special system of maintenance for the sand-clay and topsoil road, if you hope to keep it up to its highest efficiency, and the patrol system has proven very satisfactory.

General Instructions to Patrolmen

1. Inspect your road for its entire length during a rainy day and locate all holes, which will be easily noted, as they will be filled with water.

2. Use the road drag immediately after a rain, before the water drains off or penetrates the surface of the road.

3. Fill all holes and depressions that cannot be evened up with the drag, using good material of the same class of which the surrounding surface is made, and then go over the section again with a drag.

4. Never use worn-out material, sod or sand from the side ditches, but obtain fresh material of the same character as the balance of the road.

5. If the road surface is rough, run a spiked-tooth harrow over it while the road is still wet, and this will very materially increase the efficiency of the drag.

6. In dragging the road, drag from the edges of the surfaced portion of the road toward the center. Be careful never to drag any material from the unsurfaced portion of the road onto the surfaced part.

7. Be sure after dragging the road that no ridge has been left between any portion of the road and the ditch. At times a one-horse cultivator can be used to advantage in removing the ridge that may have been formed between the wheel rut and the ditch. The drag should be used immediately afterwards to bring the surface of the road back into shape.

8. Remove all glass, tin cans, nails and rubbish of whatever character that you may find on the roadbed.

9. See that all culverts are clear, with outlets and inlets in good order, and that the water can run freely in the ditches.

10. The old surface of the road must be cleaned and roughened before new material is added.

Cost of Maintenance

The cost of maintaining the sand-clay and topsoil road as outlined above will vary from $50 to $150 per mile per year, according to the width of the road and the amount of traffic that the road has to sustain.

The sand-clay or topsoil surfacing can be used economically with increased traffic until the cost of their maintenance, plus the interest charge on the cost of constructing the surfaced portion of the road, is less than the interest charge on the cost of the harder surface, plus the cost of maintaining this harder surface. With increased traffic the time will come when under that traffic it will cost more to maintain a topsoil or sand-clay road than it will to pay the interest and sinking-fund charges and a sufficient amount to build and maintain the harder surfaced road. At such times it is not economical to retain the topsoil and sand-clay road.

Roadside Trees in North Carolina

By J. S. Holmes, State Forester,
North Carolina Geological and Economic Survey

Most of the roadside trees in North Carolina have been selected in a very haphazard and purposeless way. They have escaped the axe of the road-maker because they were not fit for his use, and they have not been cut by the lumberman or firewood cutter because it would cost more to market them than they would be worth. Their only excuse for being there is that it has never been worth anybody's while to cut them down. The reason for this is that we have never consciously realized the value of roadside trees.

The advantage of having trees along the highways may be briefly summarized as follows:

1. Shade is a great protection to certain kinds of roads because it retards their drying out, and so prevents their rapid wearing.

2. The shade of trees along the sides of the roads retard very materially the growth of underbrush, and thereby much reduces the cost of cleaning up the roadsides.

3. Trees are a protection to the traveling public from sun and wind.

4. Many trees have considerable value as producers of food, such, for instance, as the various nut trees and our common orchard trees.

5. Their esthetic value cannot be overestimated. The sense of beauty can be developed in us, and the pleasure and satisfaction in life thereby greatly increased. But beauty has also a financial value, for tourists and visitors seek beautiful scenery, and they bring local markets, money and settlers.

In North Carolina there are many roads which have no trees or only poor ones; these would be greatly improved not only in appearance but in condition by a proper arrangement of roadside trees. Concrete, macadam, and shell roads should be shaded, while sand-clay and dirt roads even if not benefited, will be little hurt by having trees along their north sides, and at a somewhat greater distance from the road on their east and west sides. The south side of dirt roads and usually of sand-clay roads should be more or less open to the sunshine, especially in the winter and spring. There are two ways of securing roadside trees: reserving and planting. Instead of cutting down all the brush and young growth along the sides of the road, here and there thrifty young trees of suitable species can be reserved for future shade trees. In making such reservation, suitable kinds and properly shaped thrifty individuals should be selected. Most of the oaks, ash, and elms make good roadside trees, as do also the beech, hackberry, linn, sycamore,

sweet gum, sugar maple, and yellow poplar. Such nut trees as black walnut, pecan and shell-bark hickory make beautiful as well as very useful shade trees.

Conifers and other evergreen trees are not generally recommended for roadside trees, because the winter sun is desirable on nearly all roads. The position of the tree must also be taken into consideration. It is usually better to have them well back from the edge of the road, especially if nut trees are used, and not too near together. From 40 to 60 feet apart is close enough for our larger native trees. The tops of these trees should never be cut back, but the lower branches may be trimmed off. They will thus be encouraged to branch well above the line of vision of the traveler.

In planting roadside trees, a greater selection of species and position is possible. Some trees of foreign origin have points of advantage and may be used in certain cases. The ginkgo and larch are taper-pointed and tend to throw shade only immediately under them; while the Lombardy poplar with its perpendicular branches makes almost no shade at all, and yet very pleasantly breaks the monotony of a level landscape.

Purely ornamental trees can be reserved or planted in many places to advantage, especially along straight reaches of road where they will not interfere with seeing across corners or curves. Dogwood and sourwood are our most ornamental roadside trees, and can be found for reservation almost anywhere, while crab-apple and wild cherry are desirable where the tent caterpillars can be kept out of them. In addition to these, the crepe myrtle and many of our larger shrubs should be much more extensively planted for beautifying our roadsides.

SOURCES OF INFORMATION

By addressing a communication to any of the following departments, literature regarding roads can be had:

United States Office of Public Roads and Rural Engineering, Washington, D. C.

North Carolina State Highway Commission, Commercial National Bank Building, Raleigh, N. C.

North Carolina Geological and Economic Survey, Chapel Hill, N. C.

The following magazines give excellent literature relating to all phases of public road work:

Southern Good Roads, Lexington, N. C.
Better Roads and Streets, Jamestown, Ohio.
Good Roads, 150 Nassau Street, New York, N. Y.