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ENGINEERING EXPERIMENT STATION
OREGON STATE COLLEGE
CORVALLIS, OREGON

Proceedings of the

1955 NORTHWEST CONFERENCE ON ROAD BUILDING

Sponsored by
OREGON STATE COLLEGE
School of Engineering
and the
Student Chapter of the
American Society of Civil Engineers

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1955 Northwest Conference on Road Building, February 10-11, 1955, Oregon State College

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Oregon State College
Presiding

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10:00 THE USE OF PORTLAND CEMENT IN STABILIZING SOIL FOR ROAD CONSTRUCTION. F. Gunner Gramatky, Contractor, Sacramento, California

11:00 A LONG RANGE ROAD PROGRAM FOR UMATILLA COUNTY. John R. Gray, County Engineer and Roadmaster, Umatilla County.

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Afternoon

BEN B. IRVING
President, Association of County Engineers of Oregon
Roseburg, Oregon
Presiding

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SIDNEY KING
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Managing Engineer, Pacific Coast Division
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PORTABLE ASPHALT MIXERS. Al Shurtz, President Asphalt Equipment Company, Inc., Fort Wayne, Indiana.

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M. POPOVICH
Assistant Dean of Engineering
Oregon State College
Presiding

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Oregon State Highway Department.

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4:15 MODERN APPROACH TO LOCAL TRANSPORTATION PROBLEMS. Bob Glenn, Associate Engineer and Extension Representative, Institute of Transportation and Traffic Engineering, University of California.

WELCOME

George W. Gleeson

It is my honor and privilege to again welcome you to an annual roadbuilding conference. Those who have attended in the past have given us to understand that these conferences are both enjoyable and profitable. I can only hope this conference is no exception. As you realize, no doubt, these conferences are an annual event which we share with the University of Washington upon an alternate year basis. It is significant that, regardless upon which campus the meetings are held, there is an enthusiastic attendance from a rather broad area.

I wish to say a few words about the Ford——specifically the 1914 Ford. I pick that year as significant because mass production of the automobile had become a reality, and it is as far back as I can remember.

In 1914 the automotive industry built a few over 548,000 cars, of which Ford built 300,000. Choice was somewhat limited and it used to be said that "you could choose any colored Ford that you wished so long as it was black." You started the engine with a crank—the self-starter was not introduced until 1918.

The 1914 Ford had one characteristic above all others, it was cheap. Specifically, the stripped down model (there were no others) cost $975, FOB factory. I am not so concerned about the quality of the 1914 Ford as I am the price. If my information is correct, the 1914 $975 would be the equivalent of approximately $3,624 in 1954 money. The figures would indicate that the class of people in a financial position to purchase a Ford in 1914 should be buying a Cadillac in 1954, but they don't. Ford still built 1,300,000 units out of industries' 7,340,-617 in 1954, sold the units on a stripped down basis for $1,626 FOB, and then attached an approximate average of $500 worth of extras.

The reason the 1914 Ford class of buyer does not purchase the 1954 Cadillac is obvious, of course. The $1,100 or $1,200 differential goes to keeping up the payments on the television, the washer-dryer, the outboard motor, the deep freeze, the new range and refrigerator, and the F.H.A. loan, et cetera. Briefly, the people of the United States are possession-minded—gadget-minded if you will—and the car is their most cherished possession. It is the "darling" of the American people. Fifty-eight per cent of all spending units in this country own a car, and the only segment of our population in which car ownership falls below 50 per cent are those who are retired, and that is only because so many of the retired persons are just too feeble to drive.

We don't need four-passenger automobiles, and six- and eight-passenger cars are pure extravagance. We need only about a 3.5-passenger automobile since there was a car for every 3.4 persons in 1953. In fact, if you live in California, you need only a 2.5 passenger car. In Oregon it would be a little small, a 2.8 size would fit better. Washington would need a still slightly larger unit at 2.9. Regardless of size, there are a lot of cars, better than 43,000,000 passenger cars alone, and a total of more than 56 million automotive units of all types.

Again, if my figures are correct, if all of the cars were placed in operation at the same time on all roads of the country there would be about 17 cars per mile of road, or roughly 8 cars per mile going in each direction. Of course the latter figure is wholly fictitious since much of the road counted in the 17 cars per mile is one-way, and sometimes not that. Actually, to get all the cars on surfaced mileage in the country would result in about 13 cars in each direction per mile, which is not quite bumper to bumper but is less than 500 feet apart. Of course not all cars are on the road at the same time, as the parking problem so definitely indicates.

In all honesty, the magnitude of the job you people have frightens me. You are associated with and a very necessary part of an enormous segment of the American economy upon which all people depend and in which most people participate. No very broad decision can be made in this age without consideration of the automobile, its provision, servicing, housing, parking, and most important, the roads upon which it travels. It really takes no very broad comprehension or imagination to envision a 40 billion dollar improvement program on the federal aid systems alone. All you have to do is drive and not be counted among the 38,000 who didn't make it last year.

I wish you success in your meeting and sincerely hope that it contributes in some small part to the solution of one of our largest, if not most important, problems of American living. We have fewer persons in the Northwest than in many equal areas of the East and, consequently, fewer cars. However, our problems are not less. We have more road mileage, fewer persons per car, and fewer cars per mile of road and, as a result, less taxable wealth over which to spread costs. Perhaps our problems are magnified by the greater distances and fewer persons.

THE USE OF PORTLAND CEMENT IN STABILIZING SOIL FOR ROAD CONSTRUCTION

F. GUNNER GRAMATKY

In the last several years much progress has been made in road and highway construction methods. The design and soil stabilization for bases and subgrades are definitely steps forward. However, there is much yet to be done and learned in this field.

At the present time, the most popular and acceptable method of stabilizing soils and aggregate for base and subgrade is with the use of Portland cement. The use of cement for this purpose is not new. It has been tried in various materials and methods for 20 years. The results of these projects or tests have contributed such information that theories and practices can now be developed.

It is easy to understand that the mixing of cement with a normal base material tends to increase its strength and bearing value, but as a greater value, it has been found that by introducing a small amount of cement into base materials the plasticity is reduced and swelling of that material under extreme wet and dry conditions is largely eliminated. The amount of cement used will vary from 1 to 6%, depending upon the type of base material used and the strength desired.

In the section on Cement Treated Subgrade and Cement Treated Bases in the State of California Division of Highways Standard Specifications, dated August 1954, three classes of cement treated bases are designated as follows:

Class	Quantity of cement by weight of dry material Per cent	Minimum compressive strength of compacted mixture at 7 days psi
A	3-½ to 6	650
B	2-½ to 3-½	350
C	1 to 2-½	None

There are many engineers who believe that the cement content should be so adjusted that the compressive strength will be as near as possible to 600 pounds per square inch. With many base materials it is possible to get much higher strengths, which is believed undesirable because this tends to cause large checking and slab heaving.

Cement is now used extensively in stabilizing crusher-run base and well graded aggregate base material for eliminating that swell. It is also used with great success in such extremes as material very high in clay content and sandy material low in fines. However, some clay in the material to be stabilized has been found to be very helpful.

To obtain the most satisfactory results in cement stabilization of base materials, it is necessary to adhere to certain principles in its construction. Normally, the material to be stabilized will be placed on the roadway in a windrow, or bladed into a windrow from the roadbed. Care must be taken that the windrow is of uniform size so that the resulting mixture will also be uniform. The cement is then spread along the top of this windrow from sacks deposited on the windrow at measured distances, or spread on the windrow with a bulk cement spreader. With either method there should be no difficulty in obtaining a uniform spread at the cement content desired. As this material is mixed in a traveling mixer, the necessary water is introduced into the mixing chamber through an accurate metering device so that the mixed material deposited on the roadbed has the exact optimum moisture content. The types of mixers that give most satisfactory and uniform results are those of the auger or pugmill types. These use a kneeding or squeezing action while mixing instead of merely agitating.

Mixed material must be spread and compacted promptly in such a manner as to avoid segregation or drying of the material. While shaping and rolling of the material is in progress, it is often necessary to spray the surface with a light fog spray, as it tends to dry. In most cases it is necessary to continue the fog spraying until the bituminous seal is applied for the purpose of curing. The entire operation should be completed in not more than two hours after the water is introduced into the mix.

The proper use of cement stabilization of poor base materials is not just a fair economic substitute, but in almost every case has been equal to or better than untreated crushed-rock bases.

Discussion:

QUESTION: How much importance do you attach to the curing time required before you can let traffic on it? Do you consider that three or four days will suffice, or do you let traffic on it immediately?

ANSWER: In the Class A cement treated base, the California State Highway requires seven days, but in the Class C that is not important. I have seen traffic allowed on it immediately. We have had to do one side and allow traffic on it while we were doing the other side. We would work one side one day and turn the traffic on it the next day. If you can get the compaction right during the first two hours, you are not going to move it anymore. It is going to stay there and any highway traffic is not going to hurt it. That is my feeling and one that has been shared with me by many engineers and construction men throughout the West.

QUESTION: I noticed in your film you showed the use of the auger or pugmill type of mixer. Is that a requirement of the California Highway Department?

ANSWER: The California State Highway Department will not tell you what to use. They tell you that they want results, and if you do not want to get segregation it has to be a machine that can mix uniformly and without segregation. They will make their tests behind you, and if they get variations of uniformity, segregation, or moisture control, they then have the right to ask you to remove the equipment from the job.

I toyed with the idea of getting other types of mixers because they are cheaper. The type I use costs me $42,000 and I thought if I could get one for $10,000 or $12,000 perhaps I had been using the wrong tool. A person can get run off a job easily enough, however, without using the wrong tool, so there is no use in sticking out your neck.

QUESTION: In one of the pictures you did not seem to be using a spreader. What is the procedure for laying then?

ANSWER: I have a spreader on that machine also, but for best results start the initial rolling as soon as possible. This gives the best compaction. The windrows of a mixed material can be spread with a blade. Use a practically straight blade and go through and knock down the windrow to fill approximately the area and width you are going to lay. Get on it with the rollers for compaction and then polish it up afterwards with a blade. After you have the initial compaction in the mix it is very much easier for the motor grader to polish off a road and get it to the right shape and grade. It is important to get compaction while the material has just the right moisture content and no segregation.

QUESTION: What is the possible use of this type of construction for paving driveways and access roads?

ANSWER: This type of treated material is the base. You need a wearing surface over it because even with your best graded crushed-rock bases there will be abrasions. It does not have an extremely high abrasive value, but on a good base you do not need the durability of a wearing surface that you do on a poor base. We have done some jobs back in the hills where we merely put a double armor coat on top of a very poor base which was stabilized just enough to give it a light wearing surface of some kind. This has been done on state highways in California.

A LONG RANGE PLAN FOR THE UMATILLA COUNTY ROAD DEPARTMENT

JOHN R. GRAY

Imagine yourself rather unceremoniously dropped into the heart of a Brazilian jungle, with only your own two hands and your mind as the tools with which to save yourself. What would you do? Compare this illustration to my own case with the Umatilla County Road Department some 13 months ago. Here is what we did!

First, a two-man survey party made a field survey in their slack time to determine how many miles of road were actively maintained by the Umatilla County Road Department. They also determined the condition of the road, width, type of surfacing, and depth of surfacing.

In conjunction with this roads inventory, the group inventoried all county bridges with regard to length, width, type of construction, materials used, and general condition. At the same time, another group was making a survey inventory of all county equipment.

A quick study was also made of existing conditions at our two outlying maintenance stations—at Milton and at Stanfield, Oregon.

Another survey, a labor survey, was coordinated with the equipment survey. This survey was taken primarily from payroll records and labor was coordinated to needed or proposed field projects.

The last survey made was one of the most interesting of all our surveys. This was the preparation of a rock availability map—a geological map, if you please—of the entire county of Umatilla. This map was prepared by the assistant roadmaster while he was undertaking his daily duties, and showed where the various types of rock existed in our county.

What did we then propose to do in regard to roads, bridges, equipment, maintenance stations, labor, and rock?

From our roads inventory we found that we actively maintain approximately 1,800 miles of road. Of this amount, approximately 200 miles are paved. We now pave about 20 miles of road per year, and it was felt that approximately ¼ to ⅓ of our active roads system should be paved. To develop a democratic, systematic method of roads improvement priority, a network of approximately 400 miles of road was rated by two members of the Umatilla County Court, the county engineer-roadmaster, and the assistant roadmaster. The Thurston County, Washington, roads rating survey idea was used for this purpose.

After making this survey it was decided to double our present road paving plan to pave 40 miles of road per year for seven years. Following this plan for seven years would give Umatilla County approximately 500 miles of hard surfaced roads. It was also proposed that 20 miles of road be reconstructed and graveled each year for seven years, in addition to the paving program. This could be done with our present budget.

Our bridges survey revealed the real bugaboo! We had 432 untreated wooden bridges and 107 steel truss-type bridges which were in various stages of disrepair and badly needed replacement. Another fact revealed by our bridge survey was the total length of bridge replacement needed in feet. An estimated cost per foot of bridge replacement soon revealed that we would also need to double our present bridge replacement program for a 10-year period. An amount also was added to include bridges needed at new locations.

It was interesting to note this past year that 54% of the estimated doubled program was completed at one-half the estimated 10-year budget needed. In other words, our present rate of bridge replacement will take approximately 20 years unless the proposed rebuilding plan goes into effect as proposed.

A cursory glance at our equipment inventory revealed many surprising things. The most surprising fact of all was that most of our machines were old enough to vote! They were over 21 years of age, and were piles of junk. The need for a definite equipment replacement was evident. To develop this plan, estimates were made of the present value of each machine, the useful life of a similar new machine, the remaining life of each machine, and the amount of money needed each year to replace each vehicle. Modern-day vehicles not now owned by the Umatilla County Road Department, but urgently needed, were included in the proposed equipment replacement plan.

From the development of this plan it was found that $155,000 were immediately needed to replace obsolete equipment, and $50,000 would be needed annually to continue a definite equipment replacement plan. The Umatilla County Road Department now spends annually $49,000 for equipment replacement.

The labor survey revealed the maximum "needed labor" increase would not exceed 10% of our present labor budget. In dollars, this would not increase our proposed budget more than $20,000 a year.

It has already been stated that the rock acquisition survey proved to be one of the most interesting of all the surveys made by the Umatilla County Road Department. On the rock survey map, as prepared by the assistant roadmaster, circles of 4-mile radii were constructed with their origin at one of the definitely located rock sites. Without overlapping the circles except in a few instances, this procedure revealed that 40 sites were needed to serve as rock production areas for the Umatilla County Road Department roads system. The 4-mile radius circle idea was chosen to indicate that it was desired to haul rock not more than 5 miles "as the truck drives." It was proposed that two acres of land be acquired for rock production and one acre of land be acquired for stockpile purposes at each site. To date, 14 of these proposed sites have been *donated*! This even dispersion of rock sites will simplify a rotation plan for the Umatilla County Road Department rock crusher.

A scheduling and financial plan was presented with and included in the long-range plan for the Umatilla County Road Department. However, time will not permit any discussion of this plan. Most of the financial plan pertains to finance problems peculiar to our own county at the present time.

To date our long-range plan is progressing on schedule in regard to bridges, equipment, maintenance stations, and rock sites. We hope and intend that the paving plan will follow as well.

In closing, I should like to state that most of the work was done as a part of the daily work routine and did not overburden any section of our road group. Whether planning costs or not, long-range planning is the final answer to all road problems.

Discussion:

QUESTION: I believe you said that you had a demand for some $665,000 worth of equipment. Is that correct?

ANSWER: No, $155,000 worth of equipment.

QUESTION: Do you plan on contracting any of this planned work?

ANSWER: As far as the heavy base construction is concerned, it is my hope that we will not do so. As far as the paving is concerned, I just don't know. We have both schools of thought. We, in this plan, considered that it would be done by private contractors. I have heard rumors, and I have delved into it quite a bit, that it would be cheaper if we would purchase our own machines and do our own paving. I might add that in our department we do not feel that we can afford asphaltic concrete, even though it is possibly the best substance in our area to be used on heavily traveled roads. Therefore, we have used macadams and road-mix materials. The type of paving we did last summer, about 8 miles, was done with a road-mix machine with which I was not too well pleased because it left lean spots when a tanker was emptied and fatty spots when it was refilled. They do make road-mix machines that do not do that, and I feel that type of machine would probably be the best for us.

QUESTION: In this survey you made, do you think that in using your own forces you will get grading done cheaper?

ANSWER: I can answer that two ways. Let's go back to the idealogical plan. We felt we would probably have to build the road ourselves. However, in the past year we will have spent about another $600,000 toward completing this $900,000 job, which so far has cost us $600,000. We have been running cost analyses all the time to find exactly how much it is costing us to build our own bases and roads. This long-range plan, I might add, was set up to be just as flexible as possible. When we find out it costs less to do a job another way, we'll do it that way. This plan was merely the skeleton to follow.

REMARK: I knew Umatilla County 30 years ago, and at that time it was one of the best counties in the state, with a good man right up at the top as engineer. He was then discharged because the board knew better than he, and they really made a mess of things. I can fully appreciate the mess you have to deal with now. When you get it all cleaned up maybe they will fire you, too.

ANSWER: Thank you very much for your comment.

QUESTION: Do you have any cost figures on what it costs you to lay a permanent wearing surface?

ANSWER: So far as the rock production is concerned, we have. Since our crusher is only 27 years old (it's just a punk) we have roped in a time or two (and I'm serious when I say it) contractors to crush our rock with our machine. It doesn't help the machine, but it is so old you can't hurt it. Rock production under that basis has cost the Umatilla County Road Department about $1 to $1.35 per yard at our specified location, and we had to acquire the stockpile sites. In regard to the road-mix work we did last summer, which is the only one in Umatilla County on which I can base my words, on three widely separated projects we furnished the rock for the paving. The contractor furnished the paving equipment and the material to lay the paving, hauled the material to the site, prepared the surface, and rolled it. We prepared the base and the leveling course. The price varied per mile between $6,500 and the highest, which was a short section we had to haul through the City of Pendleton to a job about 8 miles away. That section cost us about $7,200 per mile.

I might add that it was a very interesting stock pile from which we had to haul, and I have had more digs about that dirty rock than about any other job I have done in Umatilla County. I mention it for only one reason. We had a mile of road we had to pave. We didn't have rock—with what were we going to build this road? We did have a stock pile of dirt south of Pendleton about half a mile. We ran a sieve analysis and some chemical tests on this stock pile and found it wasn't dirt at all. It was highly satisfactory for road-mix work. We used it, and today we have a mile of probably the best road-mix paving in Umatilla County. It worked out very well. I used that example to just point out the value of engineering where you really need it.

THE PRESIDENT'S GRAND PLAN FOR BUILDING THE NATION'S HIGHWAYS

R. H. BALDOCK

Since last July there has been a great deal of comment about the Grand Plan for highway improvement recommended by President Eisenhower. Last month an advisory committee to the President, headed by General Lucius D. Clay as chairman, made a report on a 10-year national highway program.

A highway program has few enemies. Almost everyone wants good roads, and those who have had the pleasure of driving over the limited-access freeways and expressways now built in parts of the United States, are profuse in their praise. The "fly in the ointment" is the problem of paying for them. Highway taxes are, in reality, a charge for road use. It necessarily costs more and the charge must be higher to provide the new and rather expensive facilities that modern traffic demands, but the savings to the road users are so great that they can afford to pay higher road-use charges to save time and motor-vehicle operating costs—tangible benefits that can be measured money-wise.

There is, however, an intangible benefit for which most motorists would pay additional money in order to enjoy the relief from driving strain that well-designed, wide, straight, safe, access-controlled facilities provide. The freedom from driving strain is worth more to the ordinary person than the actual saving in dollars and cents in time and operating costs. No legislative body wants to increase taxes, however, and road income has lagged all over the United States. This problem has become acute by the rapid increase in the number of motor vehicles and the increased number, size, and weight of motor trucks which have made many miles of road structurally and functionally inadequate. This condition has been further aggravated by the devaluation of the dollar.

As a consequence of this neglect, people in desperation have turned to the toll-road device to obtain adequate highways in traffic-heavy rural areas. Here a choice is evident. The people can use, if they prefer, the present road, which in many cases is rather narrow and crooked and, with uncontrolled access, a jeopardy to life and limb because of the side traffic from the many wayside stands. In general, such roads also have a number of hazardous grade intersections. Many of these become so dangerous that they are protected by traffic-control signals. It likewise becomes necessary to reduce the posted speeds, all of which tend to transform a onetime rather fast, safe, arterial rural highway into a narrow, congested, dangerous city street.

With this choice, many people take advantage of the toll roads and, as a consequence, the use of toll roads has exceeded all expectations. The toll charge for use of such facilities varies from one cent to four cents per mile for passenger cars, with correspondingly increasing rates for trucks. The rate for passenger cars compares to an equivalent of from 15 to 60 cents per gallon gasoline tax—rates which, when spelled out in this manner, appear to be outrageous. The road user pays sooner or later for almost all of the road facilities in the nation, and he must pay from one-fourth to one-third more for toll facilities than for free facilities.

There are many reasons for this greater cost of toll roads. Among these are:

1. Toll roads are generally built with revenue bonds which carry higher interest rates than general obligation bonds.

2. The high cost of financing forces a shortening of the time limits of construction which, in turn, increases construction costs because of the payment of overtime and the performance of work under adverse weather conditions.

3. The cost of toll collection is also a considerable item.

It is deplorable that these same roads could not be realized by reasonable increases in road-user taxes supporting general obligation bonds and in the selection of projects in order of priority, depending upon traffic needs. The State of California has built many miles of metropolitan freeways without resorting to tolls, which is much to its credit. Likewise, the State of Oregon is now building about 165 miles of rural freeways, 20 miles of urban freeways, and many miles of controlled-access throughways that are nearly up to the freeway standard. Oregon is the only state that has built freeways in the purely rural sections outside of the metropolitan areas, except in the eastern states where a toll is charged. These roads in Oregon have been built with federal-aid funds, state funds, and proceeds from the $72 million bond issue authorized by the Oregon State Legislature in 1951 and 1953.

Most of the toll roads and freeways built in the past ten years have been on parts of the interstate system. However, the progress has been so slow and the responsibility of the Federal Government to build this needed national system so great, due to its importance to the national defense, that the Clay Committee has recommended that the Federal Government take over the major job of building the nation's interstate system comprising some 40,000 miles and having an estimated cost, including urban connections, of about $27 billion. It is proposed that the states furnish $2 billion and the Federal Government $25 billion in the next 10-year period; also, that the Federal Government is to furnish

$600 million a year for the other federal-aid systems and $22.5 million a year for forest highways. The entire program recommended by the Clay Committee is for $101 billion. Of this $101 billion, $33 billion represents the cost of city streets and county roads, $41 billion the cost of completing the federal-aid system other than the interstate system, and $27 billion the interstate system with its urban connections.

One hundred and one billion dollars is a vast sum. Its magnitude is almost inconceivable to the average person. It has been estimated that the existing tax structure and other highway revenue sources will make available for highway construction during the next 10-year period a total of $47 billion. The difference in the funds available and the funds required is, therefore, $54 billion.

Now, what caused this tremendous demand that makes such a large road expenditure necessary? Reduced to its simplest terms, the highway problem is this: Traffic has expanded sharply without a corresponding expansion in the capacity of the roads and streets. As a result, a major portion of our facilities are seriously overcrowded, the traffic movement is faster, and the loads are heavier than in previous years. The tendency in this direction is on the increase.

There are now 58 million motor vehicles registered, which equals one for every 700 feet of traffic lane in both directions on all the streets and highways of the nation. Every man, woman, and child in the United States could ride at the same moment in the motor vehicles of this country without being crowded. This gigantic fleet traveled 557 billion vehicle-miles in 1954. The interstate system, which includes a little more than one per cent of the nation's mileage, carries about 20 per cent of the rural traffic. While the existing traffic jam is bad enough, prospects for the future are even worse. It is estimated that motor-vehicle registration will reach 81 million by 1965, an increase of 40 per cent. It is expected that there will be 814 billion vehicle-miles by 1965. By 1975, there is estimated to be 92 million vehicles on our highways.

In determining the estimate of $101 billion for all the nation's highways and streets, the criterion used was that the interstate system during the next ten years should be constructed to standards adequate not for 1965, nor for the year of completion, but for the year 1975, 20 years hence. It is further believed that, with minor additions, the system will be satisfactory until 1985. With reference to the other portions of the federal-aid highway systems and the county roads and city streets, the estimates were based upon building in the next ten years the requirements for that period.

Now, how is this to be financed? With respect to the interstate system, the Committee recommends the establishment of a federal highway corporation composed of three citizens appointed by the President and confirmed by the Senate, with the Secretaries of the Treasury and of Commerce as ex-officio members. On matters involving highway location, the Secretary of Defense would also serve as an ex-officio member. The Commissioner of the Bureau of Public Roads would serve as executive director. The Corporation would be responsible for the development of financial policies. It would also serve when necessary as an appeals board to resolve major points of difference between the federal and state authorities which may arise under the program.

Presently, the federal government levies a two-cent federal motor fuels tax and a six-cent tax on lubricating oils, and it is proposed that these taxes be continued and the funds credited to the national authority. Such taxes now yield about $1.1 billion annually and are expected to yield $2.0 billion per year in 20 years. Federal-aid funds available for federal systems other than the interstate would continue at the rate of $600 million per year, with $22.5 million per year available for forest highways. The $600 million yer year will afford approximately the same federal aid as was provided under the 1952 Federal-Aid Act, which is about $100 million below the funds provided under the 1954 Federal-Aid Act for all federal-aid systems other than the interstate system. The remainder of the yield of the combined taxes would be devoted to the financing of the interstate system, including urban radial, circumferential, and approach roads.

Bonds ranging up to 30 years would be issued by the federal government to an amount of approximately $20 billion, and the bond and cash funds would be used to provide an expenditure of $2.5 billion of federal funds per year on the interstate system, while the states would be asked to put up $200 million on the interstate system each year for 10 years.

While it is possible to finance the interstate system under the terms as outlined, it will be quite difficult to complete the other portions of the federal-aid system, costing about $41 billion, and the city and county systems, costing $33 billion, in a 10-year period, without major increases in road-user and property taxes. It has been estimated that such a program would require the equivalent of about a four-cent gas tax over the nation, besides an increase in property taxes. While the interstate system may be built in 10 years, the other systems cannot. Income estimates indicate that 15 years is a more reasonable time for all systems.

With present local revenues, the state highway construction program in Oregon will amount to about $53 million annually under the President's Plan as recommended by the Clay Committee. The expenditures for construction, including right-of-way costs during the past two years and for the present year, will average about $43.5 million annually. This is during the period of the expenditure of the bond funds. If the President's Plan does not materialize, the program will soon shrink to about $23 million per year. Of the $53 million prospective annual highway construction expenditure, $35 million will be spent on the interstate system, $2.5 million on the forest highway system, and the balance on the other federal-aid systems.

The plan, as recommended by the Clay Committee, also includes the reimbursement to the states of part of the capital investment in sections of the interstate system recently built to acceptable standards either by the toll-road plan or by the use of state funds obtained from the sale of bonds or from current revenues. Forty per cent of the capital so invested between the years 1947 and 1950, inclusive, and 70 per cent of the capital so invested between the years 1951 and 1954, inclusive, will be paid to the states for expenditure on approved projects on the other federal-aid systems. If this recommendation becomes law, Oregon would receive an amount which has not yet been accurately determined, but will be perhaps as much as $50 million at the rate of $5 million per year for 10 years.

The Clay Committee further recommended that 100 per cent be paid to states for new toll roads of acceptable standards built on the interstate system subsequent to the year 1954 for expenditure on approved projects on the other federal-aid systems. The tolls would be kept on such roads until their costs had been amortized. It is my opinion that this feature of the plan should be opposed, in that it would encourage the building of a more costly type of road and would not hasten the building of the interstate system to any appreciable extent. The real danger lies in the fact that this is a way by which federal funds can be siphoned off to build other parts of the federal-aid system and, since funds for such purposes are so scarce, pressure will be brought to adopt the plan. Ironically, the users of the main-line highways will be forced by this plan to pay exorbitant rates so that other highways, which they seldom if ever use, can be built.

To briefly review the situation, it is readily apparent that the highway engineers will be greatly pleased with this program, as it will complete the dream of a lifetime. All of the drivers who will have occasion to use these new roads will be delighted with them. The contractors will be glad to have work over a long period of time. This will give a great impetus to the economy of America. It will encourage the production of machines of all types and the use of both raw and manufactured products, which will eventually affect all businesses to a greater or lesser degree. Presently, one out of every seven workers in the United States makes his living out of some facet of highway travel. This number will be increased if the President's plan is put into effect.

Not all people will approve this program. Many people who are not on the interstate system will find fault with it, after first attempting to have their roads placed on the interstate system (which, of course, is doomed to failure). Insofar as Oregon is concerned, the interstate system consists of US 30 (the Columbia River Highway and Old Oregon Trail) from Portland east to the Idaho line near Ontario, and US 99 (the Pacific Highway) from the Washington line just north of Portland to the California line south of Ashland. At least 95 per cent of the interstate system will have to be relocated, and on a limited-access design, which means that there will be no slowdown for turns, no crossing of traffic streams, and there will be very minor, if any, access to the side. Many people catering to the traveling public, such as service station and motel operators, may object, but in the long run their business will be increased because more people will travel because of these wonderful superhighways. Being access-controlled, with easy access to the cities and towns where the motels and service stations are now located, present investments will be preserved since no new facilities of this kind can spring up along the freeways.

It has been estimated that there can be found enough engineers, contractors, and others to do this great job in the period of time stated. Actually, in proportion to the gross national product, the expenditures would not be out of line.

A truly great President has proposed a Grand Highway Plan and has pointed out the means of its accomplishment. Its prosecution is vitally necessary for the economy of the nation and for the defense of this country. It is a challenge to our courage, to our ability, and to our foresight to build a system of roads to move the goods and services of an expanding American economy. If we fail to do so, our expansion will cease and our scale of living will rapidly decline. The motor vehicles and highways form the keystone of the American way of life.

NATIONAL TRENDS IN COUNTY AND LOCAL ROAD FINANCING

Ben F. Ostergren

History of highway administration

Prior to 1900, control of highways, roads, and city streets was almost entirely the responsibility of counties, cities, towns, and villages.

Funds were very limited and the profession of highway engineering was practically unknown. Of the 150,000 miles of surfaced rural roads in 1900, 72% were gravel, 24% water-bound macadam, and 4% of miscellaneous materials.

New Jersey initiated state aid to counties in 1891 and six other states had taken this step by 1900.

Between 1900 and 1920, there were marked changes in the types of roads built. It was in this period most of our state highway departments were created. Such departments were first established to administer state grants-in-aid to local units for road improvements, with little authority as to location or character of construction. Next, these departments were made responsible for construction with state funds, but completed roads were turned over to local units for maintenance. It was not long, however, until state highway departments were made responsible for all operations with state funds.

Secondary road system

Of the almost 3 million miles of rural roads in the United States, about 2,537,000 miles are secondary roads that serve the land and connect the farms and crossroad settlements with the main highways. The counties have control of 1,709,000 miles of secondary roads, and the town and township governments have control of 609,000 miles. There are 219,000 miles of secondary roads under state control.

In the federal-aid secondary highway system as designated by the Act of 1944, there are now 482,972 miles of the more important secondary roads. It is estimated that 55% to 60% of this mileage is under county or local control, and the balance is under state control.

County and local road responsibility

More than 18,000 local governmental units have an interest of some kind in local rural roads. These include about 2750 counties, 14,500 towns and townships, and 950 special road districts.

In New England the local roads are largely controlled by the towns, and in Pennsylvania by the townships. In the southern and western states, the counties handle local road affairs.

With some exceptions, the counties in the rest of the country have charge of the more important local roads and the townships have charge of the remainder. The townships in a number of states have voluntarily given over their road responsibilities to the counties. In Delaware, North Carolina, Virginia (except in three counties), and West Virginia, the states have taken all rural roads under their control. The road systems controlled by these local governments range from 2 miles to 7000 miles in length. Their income for highway expenditures varies from less than $500 to more than $10 million a year. The personnel of these highway units varies from a single part-time worker to organizations with more than 500 employees. In these local road units, highway administrative practices vary greatly.

Highway finance

In 1904 state highway department expenditures were about $2.5 million compared with $57 million for county and local highway departments. In 1906 state and local spending had reached a total of $75 million a year for rural roads and $300 million a year for city streets. Money came from property taxes. It was not until 1927 that state highway expenditures had about caught up to the expenditures of county and local road departments. In that year, the state highway departments spent $639 million compared to $643 million for the county and local highway departments.

Highway improvement was a small scale operation with weak financial support until the advent of the motor vehicle. Previously to that, the states, counties, and cities received most of their highway income from property tax. The state governments which have been able to exploit other sources of revenue have relied much less on property taxes than have the counties.

Vehicle registration fees

New York, in 1901, was the first state to require registration of motor vehicles. This was recognized by New York and other states as a good way to collect taxes for highways from the people who use them.

In 1915 the income from registration fees had reached $18 million a year. By 1917 every state had a motor-vehicle registration law.

Gas tax

In 1919 Oregon started to collect a 1 cent per gallon tax on gasoline to provide funds for highways. In the next 10 years every state had adopted such a gasoline tax. In 1930 the states collected $495 million from this source; in 1945 it amounted to $784 million; and in 1952, $1,968,000,000. State gasoline taxes now range from 3 cents to 7 cents a gallon. The average for the country is 4.8 cents, and the federal government collects a gasoline tax of 2 cents per gallon.

Imposition of levies upon highway users is not limited entirely to the federal government and the states, although many states forbid most forms of highway-user taxation by subordinate units. There are a few states in which such imposts are permitted.

Property tax

The general property tax has continued through the years to be an important source of county and local road revenue. The accepted opinion is that use of general property taxes is justified when the improvements to be financed are of general community benefit, or when the benefits accruing to property are expected to be more or less proportional to existing property values. These property taxes have been the principal source of direct tax revenue available to counties for support of highways, and it is probable that this situation will continue for years to come.

Federal aid

There are 482,972 miles in the federal-aid secondary system. It is estimated that 55% to 50% of this mileage is under county or local control; the balance under state control. In many instances the states and counties are cooperating in the administration of this program.

State aid programs

In Iowa and Minnesota there have been state-aid programs to the counties for many years. In these states each county highway organization is under the management of a professional engineer. It is generally agreed that performance on the county level is good, and there is very little pressure on the part of the public to increase the present state mileage which in Iowa is 9700 miles and in Minnesota 11,000 miles. It is significant that these two states rank highest in raising local money for the construction and maintenance of county and local roads.

The cooperative relationships which have been created through the administration of the federal-aid secondary program and state-aid programs to the counties have had a good influence on building stronger county highway organizations.

There are 10 or 12 states where such good relations have existed between the state and counties over a period of years. Not so long ago, Alabama initiated a state-aid program to the counties in which provision was made to extend financial aid to the counties exercising certain control over county highway administration. Another southern state, Mississippi, has more recently elected to follow this same general pattern. Here, state aid is given to the counties providing they secure professional engineering services and adhere to certain design standards.

Trends

To indicate a possible trend in revenue collections, the income for county and other local units for highways for 1947 included $331 million in property taxes, $384 million in highway-user revenue, an estimated $90 million in federal aid, $106 million in bond proceeds, and $18 million from miscellaneous sources. The 1953 figures show an income of $480 million in property taxes, $666 million in highway-user revenues, an estimated $137 million in federal aid, $73 million in bond proceeds, and $42 million from miscellaneous sources. Total highway expenditures for these units increased from $820 million in 1947 to $1,262,000,000 in 1953. Construction expenditures increased from $261 million to $463 million, and maintenance from $431 million to $634 million.

In 1921 the total outlay for county and local rural roads amounted to $610 million, $337 million of which went for construction. This figure was not equalled until recent years. In fact, there was a general declining tendency until construction expenditures reached a low point of about $80 million in 1944. This trend, however, has now been reversed and it is estimated that construction expenditures in 1954 reached $488 million.

Payments for the maintenance and administration of county and local rural roads have fluctuated widely, although within the last 10 years there have been evidences of an upward trend. This has resulted in a record high of $695 million estimated expenditures for these purposes in 1954. Interest payments on county and local road debt mounted steadily from $34 million in 1921 until a peak of $91 million was reached in 1931. Since then the trend has been reversed. In 1954 it is estimated that $28 million was expended to meet interest obligations.

The income for highway purposes collected by county and local governments reached an all-time high of $550 million in 1928. During the depression, the yield from property taxes dropped sharply. Since then, however, except for the period of World War II, there has been a marked increase in these funds; reaching an estimated $495 million in 1954.

State collected highway-user funds allocated to the county and local road authorities in 1931 amounted to $170 million. These allocations increased to $651 million in 1953. A definite trend toward increased participation by the counties in the use of state collected highway-user funds is indicated.

SOME INTERESTING PHASES OF THE WASHINGTON GAS TAX ALLOCATION STUDY

G. A. RIEDESEL

In the State of Washington approximately 35%, or roughly $16,000,000 gas tax money is given annually to the counties for the maintenance and construction of the county road systems. There are 39 counties with road systems varying in size from less than 150 miles to over 2500 miles, and covering a very wide range of conditions. Therefore, a big problem confronting the people of Washington is the equitable distribution of the $16 million among these 39 counties. This is made more critical by the fact that for many counties the gas tax money is the principal source of highway income and that this, with all other sources of income, has not been adequate to pay the counties' road bills.

The present method of distribution has been in effect about ten years. It allocates the money to the counties on two bases: (1) the number of rural vehicles in each county, and (2) the size of the county's road system measured in terms of trunk miles. Both of these are modified by a factor intended to represent the relative cost per mile of road in each county. The factors vary from 80 to 240, or on a ratio of 1 to 3. In addition, 10% of the entire amount is divided equally among all counties. This would seem to be an equitable distribution, but there has been considerable dissatisfaction because it is claimed that the cost factors are not correct and are not determined from reliable cost figures.

At the request of the counties, the 1953 State Legislature authorized a study of the county highway problem to try to find a more satisfactory allocation formula. The interim committee of the legislature to whom the study was assigned, took the attitude that this was a problem of the counties and called on them for suggestions on how the study should be conducted and who should do the work.

The counties in Washington are very effectively organized into the Washington State Association of County Commissioners, whose executive-secretary is Mr. R. C. Watts. The county people, through the efforts of this organization and by action of many individual county boards, recommended and helped set up the procedure for the study. Also, at the recommendation of the Washington State Council for Highway Research, the study was assigned to personnel of the Department of Civil Engineering at the University and of the Division of Industrial Research at the State College of Washington.

Briefly, the plan recommended by the county people and followed throughout the study was as follows: A group of three or four hired research men were to visit each county to examine county records for their receipts and expenditures and other operational information. In addition, they were to examine and note all conditions in the county that affected road costs. These included traffic, climatic conditions, topography and terrain, local road building materials (especially soil and aggregate), rural industries, and all social conditions. A large percentage of each county's road mileage was to be inspected and rated. These hired persons were to be accompanied in each county by a visiting or observing county commissioner and county engineer from a neighboring county and by a representative of the state office of the Commissioners' Association. This was to insure uniform and impartial treatment of all counties and all districts. The investigation of each county was to be made with the help of and under the scrutiny of the local county engineer and his board of county commissioners. This plan was closely followed throughout the entire study. Cooperation and assistance received from local people in each county and from observers who visited each county were excellent.

Time does not permit a detailed account of the progress of the study. Instead, I will point out some of the most interesting conditions observed.

Probably the most interesting observations deal with the extreme differences in the counties, both in their road problems and methods of operation and in their finances. In regard to finances, we saw that the county budgets varied from $200 per mile to $1800 per mile. Maintenance costs varied from $90 per mile to $1350 per mile. Traffic varied from practically no cars per day in outlying desert or timbered regions, to 20,000 cars per day in suburban industrial and residential areas adjacent to Seattle. Standards of highway varied from primitive wagon ruts to modern four-lane highways. Rainfall and climatic conditions included dry areas with less than 10 inches of rainfall, to the Grays Harbor region which has over 150 inches of rainfall per year. Parts of Washington in the northeastern counties have a heavy snowfall of over 60 inches at a time, while other parts of the state seldom have either frost or snow. In some counties road building aggregate is practically nonexistent and must be hauled in by truck, train, or barge for considerable distances, while in other counties the material in the side ditches provides excellent material for surfacing.

The rural industries of Washington include cattle raising, dry land wheat raising, irrigated farming, orchards, mining, logging and lumbering, fishing, manufacturing industries, military bases, public works, and recreational businesses on the lake and ocean fronts. The population varies from the more sparsely settled regions with not more than two or three families in a township to the heavily populated suburban areas, located just outside the city limits of Tacoma, Seattle, and Spokane, with all the problems and characteristics of the city. This includes summer home and country home regions on the lakes and waterfronts within driving distance of the metropolitan centers. Some counties have less than two rural people and less than two rural vehicles per mile of road. Others have over 90 people and over 40 rural vehicles per mile of road.

The administrations of our county highway departments vary from a large, well organized county-wide setup under the control of a competent engineering and administrative staff to a three-district system in which the county is divided into three practically independent commissioner districts under control of individual county commissioners. Each county in Washington is required by law to have a registered highway engineer. In some counties he is little more than a glorified record keeper who is responsible for making out the required reports to the State Highway Department and who occasionally advises on the design of a bridge or the size of a culvert when called upon to do so by the county commissioners. One county has less than \$4000 assessed valuation per mile of road, while another county has \$90,000.

We spent ten months going from one county to another making our observations. We averaged about a week in each county. After observing, recording, and discussing all of these things in each of the 39 counties, we tackled the job of organizing and evaluating the information and undertaking the construction of a new formula.

This might be an appropriate time to discuss briefly the philosophy of distribution of state collected money to smaller units of government.

There are several basic methods of distribution. The money can be returned to the taxpayers by county, city, or locality in the same amount collected. In this case it becomes merely a state collected tax. It may be redistributed arbitrarily on a basis of political expediency or on some arbitrarily statistical basis governed by newspaper circulation, bank deposits, or assessed valuation. A third method of distribution is on the basis of need, in which the money is considered a grant-in-aid governed by the financial needs of the smaller units of government. Historically, the distribution of county gas tax money in Washington State has been based on the philosophy of need. Early in this study the Washington State Council for Highway Research contacted the other 47 states to determine how each one's gas tax money was distributed. The returns were interesting. Methods of distribution were based on population, gas tax collections, vehicle registration, road mileage (both with and without cost adjustment factors), areas, property valuation, flat sums, and fixed percentages.

It was generally agreed that, to meet the needs of Washington, our method of allocation should meet certain basic requirements, as follows:

1. It should have a definite connection with the county road problem and reflect the financial needs.

2. It should be based on statistics that are reliable and easily obtained, preferably already compiled for some other purpose.

3. It should not be subject to manipulation.

4. Formula and method should be flexible enough to allow for changes in needs and conditions.

5. It should correct any existing inequities.

As I have mentioned before, the county commissioners and engineers were very active in this study. They agreed and recommended that a new formula should include consideration of; (1) size of the county's road system, (2) relative costs of road construction and maintenance in each county, (3) number of vehicles in each county, (4) county's financial situation and its ability to meet its own individual road needs, and (5) a certain amount of equal distribution to cover such items as the engineers' and accountants' salaries, inter-county traffic, and other items of cost that could not be well reflected by a variable factor. These were recommendations to the research staff and were not binding. However, it is obvious that consideration of these items would provide practically everything to be desired in an equitable formula.

Of the items mentioned, the most difficult one to handle was the figure of relative road costs among the counties. We made several attempts to establish empirical relations between the costs in individual counties and recorded statistical and engineering data reflecting conditions in the county. For example, cost of snow removal and ice control in each county was plotted against a factor which included temperature, snowfall, precipitation, and traffic. The purpose was to arrive at a snow removal cost factor for each county from impartial statistical figures. The same was done for roadway construction and maintenance costs. A curve was drawn which showed as ordinates a road cost per mile for each county and, as abscissa, a factor that included soil conditions, traffic conditions, construction cost index, and an item to allow for topography and terrain. Another attempt included an average annual cost per mile plotted against a number of arbitrary condition ratings. These condition ratings included all of the observations that had been made on all conditions during the visits to the 39 counties.

The advantages of such an empirical formula are obvious. Its use would eliminate the need of any personal judgment in determining a cost factor. If an equitable statistical factor could be established applicable to all counties, it would avoid the possibility of errors in judgment and differences in administration and operation. While these attempts at empirical cost factors were very helpful in scrutinizing the cost data and in pointing out inconsistencies and irregularities, they did not provide us with satisfactory cost factors for each county. The principal reason for this was that too many exceptional conditions existed that could not be taken care of by any statistical figures.

After a study of available information and the attempts at establishing empirical cost factors, it was apparent that no simple road cost index constructed from statistical data could give adequate consideration to the many variable conditions, problems, and operational peculiarities of the individual counties. The dollar was determined to be the only unit by which the wide range and variety of cost-controlling conditions in each county could be measured. We decided, therefore, to determine relative county road costs based on an estimated annual cost per average mile in each county. These estimated annual costs were made up of two parts; (1) an average annual maintenance estimate, and (2) an annual depreciation or replacement allowance taken as 1/25 of the estimated construction cost per mile of average road. The maintenance estimates were broken down into the ordinary operations required for shoulder, roadway, slope, and ditch maintenance; other operational costs included snow and ice control.

These estimates are based on rational calculations guided by what the better managed and more conservatively financed counties are spending on each operation, and modified by controlling conditions and traffic needs in each county. Bridge maintenance was estimated at $2 per linear foot for all bridges. This is the actual average maintenance cost for all bridges in the state.

Construction cost estimates were determined from unit costs, design quantities, and prevailing recommended standards for the traffic and conditions served in each county. They were weighted for standard conditions and costs to the extent that they existed in each particular county. The maintenance and construction estimates for each county were carefully checked against neighboring counties and other counties with similar and contrasting conditions. As a final check, both the maintenance and construction estimates were referred to the county engineers for review. At their suggestions, some doubtful figures were reconsidered and some revisions made.

We selected the value of 1/25 of the construction cost estimates as an annual depreciation or replacement allowance, after studying road life figures from Washington, Oregon, U.S. Bureau of Public Roads, and the Highway Research Board.

A comparison of the estimated annual costs per mile with the actual average annual expenditure per mile for each county shows that in nearly all counties the estimated cost is larger than the expenditure. These estimated annual costs per average mile became the relative cost factors to be multiplied by the county mileage for determining the total annual road cost of each county.

In addition to the number of vehicles in each county and the number and annual cost of each mile of road in each county, there is a third consideration which expresses a county's financial need. This, as mentioned before, is the county's ability to take care of its own finances. There is a great difference among the counties in their ability to raise their own funds. Some counties are very much handicapped in raising money by taxes due to large areas of public and Indian lands, and because of the absence of utilities, rural industries, and other taxable property. Some counties have appreciable income from National Forest Reserve Funds and other sources.

In order to take care of these inequities, a so-called "money need factor" was established for each county. This money need factor was the difference between the annual cost per mile of road and the amount of money the county could raise per mile of road from certain specified major sources of income, but not including the gas tax. This money need factor multiplied by the number of miles of road in the county expressed the county's *inability* to finance its road department.

The new formula finally selected and recommended to the legislature provided that, (1) 10% of the gas tax money be divided equally among the 39 counties, (2) 30% be divided on the basis of rural registered vehicles plus 7% of all city owned vehicles, (3) 30% distributed on the basis of total county mileage multiplied by the average annual cost per mile, and (4) 30% distributed on the basis of the counties' inability to finance themselves. The recommendation included a readjustment for a change in the number of registered vehicles, the number of miles of road, and the counties' financial ability every two years. This formula is now under consideration by the state legislature. Its outcome is not certain.

A complete report of the study has been published and has been given rather wide circulation. Copies are available from the State Council for Highway Research Section, Division of Industrial Research, State College of Washington, Pullman.

Discussion:

QUESTION: Does your formula make a greater allocation allowance for trucks than for passenger cars?

ANSWER: In our cost factor we recognize the fact that to design and build a road for heavy truck traffic costs more than a design for a light vehicle. In that way it is taken into account. In the formula itself there is no distinction made between a heavy logging truck and a light passenger car; it considers merely the number of rural registered vehicles, regardless of size or class.

QUESTION: Will counties with metropolitan areas, King County, Seattle, for example, lose by the new formula?

ANSWER: No, King County stands to gain and Pierce County will have a slight gain. Some of the metropolitan counties will lose and some of them will gain by the new formula, if it is adopted.

QUESTION: Will changing conditions make the allocation percentages for individual counties obsolete or inequitable?

ANSWER: The present law calls for a change in these percentages every two years, based upon the change in the number of vehicles and the change in the number of trunk miles. It was recommended for the new formula that certain variables be adjusted every two years. The bill as it is now written and being considered, however, requires in addition that cost factors be readjusted every four years. If this goes into effect, it will require constant study. Change in the number of vehicles or number of miles would not change the cost factors. If the cost factors are changed, however, it will require a study beyond the use of just statistical figures.

QUESTION: Does the proposed new formula work to the disadvantage of those counties who have considerable income from the national forest funds?

ANSWER: The counties having a substantial income from national forests will naturally lose on the particular 30% allocated on the basis of local financial ability. They will get a smaller share due to that 30% than they would for the other parts of the formula. In other words their deficiency, or their money need per mile of road, is relatively less than for poorly financed counties. In Jefferson County, for example, we showed their deficiency per mile of road from local sources was about $400, as compared to King County where there was a deficiency per mile of about $1,200; Grays Harbor about $1,300; and Pacific County about $1,100.

QUESTION: Does that part of the formula have enough effect to reduce their allocation below what they now get?

ANSWER: There was enough effect so that they were not very happy about it.

QUESTION: How does the formula allow for the extra cost of building and maintaining a forest road used for logging—one that costs more than roads in cheaper areas?

ANSWER: If it is on the county system it is taken care of in the overall county mileage. The fact that it is a more expensive road is recognized in the county's average annual cost per mile estimate. The average annual cost per mile in timber counties is normally greater than in wheat raising counties. If it is a national forest road it would not be on the county system and would not be considered at all in determining the county's allotment.

QUESTION: When a city like Seattle extends its boundaries to take in streets that are on the county road system, how does the change show up in the county's allotment?

ANSWER: It would show up when the new allocation percentage is figured every two years.

QUESTION: Did your study include the division of gas tax funds between cities and counties?

ANSWER: No, that was not included in the study at all. We were concerned only with the allocation of the county's share among the counties.

QUESTION: How were the streets considered in areas just outside large cities?

ANSWER: The county roads in cities; that is, in the metropolitan area outside the city limits, were given the same treatment as the ones out in the country except that the cost of constructing them and maintaining them would be considerably higher. This was taken into account in our estimated annual cost per mile.

STATE COUNCILS FOR HIGHWAY RESEARCH

R. G. HENNES

The rubber tires which now roll over our roads originated in the gummy residue in a test tube, not much more than a quarter of a century ago. The test tube was in the college lab where I was struggling with freshman chemistry, and at about the same time. That new industrial giant, the plactics industry, began with a book on the nature of the chemical bond, written by a Cal Tech professor not too many years since. The A-bomb and the H-bomb materialized out of academic dreams—or nightmares. All the electronics and nuclear physics that have changed the family living room into a TV theatre and the family basement into a bomb refuge, all the technological advance that has transformed both our daily lives and the balance of international power during the past fifty years—all this first germinated in some corner of a college campus, and then matured in the applied laboratories of industry and of governmental agencies.

Research is the very essence of our times; the secret of our national vitality. It is the ability to make a vigorous and methodical attack on a problem. We will be old, nationally or individually, only when we fail to recognize new problems, and when we are sure that we know all the answers to our old problems.

All of this is recognized by leaders in industry and government. The national administration justified defense cutback almost entirely upon the assumption that we shall be able to maintain leadership in scientific research. Every successful industry spends freely in the attempt to improve its product. Competition removes the others.

In some forms of enterprise the absence of competition removes the incentive for developing new ideas for the improvement of the product or, in other words, there is no external stimulus for research. This must be true, to a varying extent, in natural monopolies, in some public utilities, and in some governmental services. In such cases there is a special obligation to the stockholders or to the general public to provide the research which in competitive enterprises is a natural characteristic of our economic system.

In 1952 the Highway Research Board undertook a study of current highway research administration.[1] The most striking statistic in these data is the estimate that the cost of highway research activities in the several states amounts to about 0.1 of 1% of total expenditures for maintenance and construction. It would be unfair not to recognize even in this low figure an indication of progressive management in our state highways, but it is probable nevertheless that in a competitive enterprise much larger sums would be spent profitably for the sake of progress.

Surely all agencies responsible for the operation of public roads and streets conduct some informal research in the way of individual efforts to solve the unusual problems that present themselves in the natural course of events. Most frequently this is apt to occur in the field of construction materials; a troublesome aggregate, or an unexplained pavement failure.

[1] Highway Research Organization, Special Report No. 15 of the Highway Research Board, 1953.

Five state highway departments (Ohio, Colorado, Iowa, Kansas, and Maryland) have established advisory boards for the correlation of research. In general, these boards are composed of departmental engineers and college faculty, but Iowa includes county representation as well. These groups appear to be concerned mainly—although not exclusively—with physical research. Some projects studies make use of slack time of regular departmental personnel; other projects utilize the facilities of the engineering colleges.

Ten states have formal divisions in the highway departments for research into the physical properties of construction materials (routine acceptance tests do not constitute research). In another five states the routine duties of the usual planning survey divisions are expanded to include studies pertaining to administrative and fiscal practices.

Six states (Indiana, Kentucky, Florida, Virginia, Tennessee, and New Jersey) report joint research units created by contractual agreements between the department and the state university. These arrangements have tended to emphasize physical research. The oldest of these efforts is located at Purdue University, and has notably affected highway engineering in Indiana and in the Nation since 1937.

Besides the six states having joint research units, 31 states report highway research contracts. These may be sponsored by the highway department, by some other agency, or by industry. Generally, these research contracts cover the investigation of single specific problems.

California has a highway research agency of unusual importance and autonomy. The Institute of Transportation and Traffic Engineering at Berkeley has quickly become a major influence on national highway policy. ITTE has no fiscal dependence upon the highway department.

Three major research projects have been undertaken as cooperative efforts of several states. These are:

1. Maryland Test Road
2. WASHO Road Test at Malad, Idaho
3. Effect of Wind Stress on Bridges

Augmenting state efforts is the national influence of the U.S. Bureau of Public Roads and of regional groups, such as the Western Interstate Committee on Highway Policy.

One might summarize by saying that the desire for progress in highway engineering and administration has found expression in four ways:

1. Individual state highway departments are constantly engaged in the utilization of their own resources for the solution of everyday problems in design and operation.

2. The desire to utilize existing research resources has led some states to establish cooperative agreements with engineering colleges. Such joint projects tend more toward technological improvement than toward questions of administrative policy.

3. Specific economic problems often lead to specific research contracts.

4. Major technological problems sometimes result in cooperative efforts by several states, with a joint staff set up for the purpose.

The Washington State Council for Highway Research differs from the patterns established elsewhere as an outgrowth of a rather unique history of highway legislative practice in Washington. For the past decade successive legislatures have delegated the investigation of highway problems to a series of interim legislative committees. Under energetic and progressive leadership these committees have developed a remarkably successful methodology. In each instance the committee entrusts the actual job of research to a competent agency. As the study progresses, both the procedure and the results are discussed in open meetings held by the committee in all parts of the state. Prior to the legislative session, the report is presented and discussed in a formal hearing at Olympia. As a consequence of this extensive preliminary discussion, the recommendations of the interim committee are enacted into law with surprising regularity.

The people of Washington find that fact finding produces better legislation than did the former method of log-rolling and pressure politics. To encourage the continuation of this procedure, various user groups asked the 1951 Legislature to impose a special user tax for the express purpose of supporting research. At the present time this levy is $0.10 for an automobile, and from $0.25 to $2.00 for a truck. Proceeds of the tax are placed in a highway research fund from which allocation can be made on the joint action of the highway commission and the interim committee.

W. A. Bugge, director of highways, had long been sympathetic to suggestions for some sort of cooperative research arrangement. The inception of the Highway Research Fund made the establishment of an advisory body especially desirable. Thus, in June 1951, Governor Langlie established the Washington State Council for Highway Research as "an agency which can visualize the highway transportation system as a whole, including the various political subdivisions, and which can utilize the technical resources of the state institutions of higher learning." At its initial meeting the Council adopted the following statement of policy:

> The purpose of the State Council for Highway Research is to augment, correlate and classify all highway research resources in the State of Washington for the solution of the State's highway transportation problems. To this end, maximum use will be made of the research facilities of the University of Washington, State College of Washington, the counties, cities, state highway department, and any other group which has facilities to bring to bear on the economical solution of the State's many problems involving highways, roads and streets. The Council will consider for assignment to an appropriate agency any problem presented to it by the legislature, highway user group or any other representative body which has problems in the field of highways, roads or streets.

The Council has no authority and no funds. It exists solely for the service it can render to those agencies which bear responsibility for our public roads and streets. In its various studies the Council has filled a liaison function between the proposer of the problem and the actual research agency. It has screened each proposal for content of public interest; it has drawn up a prospectus for the proposed research; it has recommended a research agency; and it has deliberated upon the conclusions of each study as it has matured. In these duties the Council represents the informed judgment of the public and economic interests involved. In fact, the Council membership has been selected to achieve a balanced view of any road problem and to insure against any partisan or frivolous performance by the research agency. The membership is:

R. G. HENNES, Chairman
Professor of Civil Engineering
University of Washington

W. A. BUGGE
Director of Highways
State of Washington

RAY MOISIO
Chairman, Highway Commission
State of Washington

FRED J. DIXON
District Engineer
U. S. Bureau of Public Roads

FRED J. LORDAN
Vice-Chairman
Washington Users Conference

JOSHUA H. VOGEL
Planning and Public Works Consultant
Association of Washington Cities

E. B. MOORE
Chairman, Department of Civil Engineering
State College of Washington

R. G. WATTS
Executive Secretary
Association of County Commissioners
Olympia, Washington

The 1951 Legislature's Interim Highway Committee under the leadership of Chairwoman Julia Butler Hansen, chose to make full use of the new Council, and this policy was continued under the 1954 Interim Committee Chairman, Senator W. C. Raugust. The Council had, in fact, been conceived with the objective of fitting into the fact-finding policy of the Washington legislature, which had evolved so largely under the leadership of Mrs. Hansen in connection with her work on the Western Interstate Committee on Highway Policy.

The nature of the studies undertaken by the Council in recent years is best described by the following resumé of those projects:

1. Highway Classification

Recognizing that proposed legislation for additions and extensions to the State Highways System would soon expand that system beyond both its proper function and its financial support, the 1951 Legislature directed an interim committee to review the state highway system in its relation to county roads and city streets, with the purpose of establishing criteria for measuring the merit of any proposed change in the system. The degree of state interest in a road was recognized as a criterion for determining a road's eligibility for inclusion within the State Highway System (when the change is economically feasible). A quantative measure of this factor, termed the "Index of State Interest" was computed for every road under consideration. The Index was based upon the use of the road for personal, agricultural, industrial, commercial, and recreational transportation.

2. Natural Resource Roads

Road sections subjected to heavy truck usage in the development of natural resources may be termed "Natural Resource Roads." The forest products industry feels that its competitive position would be improved if specific sections of the public highway system were open to use by heavier logging trucks than are now permitted. It is desirable to determine whether such usage would be in the public interest and economically feasible. The first aspect of this problem requires an evaluation of the extent to which the public interest is involved in the growth and prosperity of the forest products industry. The second consideration is the size of logging truck that would provide greatest economy in log transportation over public highways, and the savings which would accrue from the operation of the optimum size truck. The third step is the determination of the increase in road maintenance cost to the State incurred by the use of the optimum weight vehicle.

3. Use of Agricultural Soil Maps in Road Building

Agricultural soil maps contain a vast amount of data which, in some other states, have been used in the design of local roads and public highways. This procedure has resulted in better roads at lower cost. The value of soil maps cannot be realized in Washington until a thorough study has correlated agricultural soils classification with actual highway performance. The study involves the digest of all available information on soils and surface geology for the State of Washington, including soil maps, classification surveys, soil analyses, descriptions, and bibliographies; the collection of these data from State and Federal agencies in the fields of soil conservation, agronomy, reclamation and plant industry; and the organization, interpretation and presentation of this information in the form most useful to highway engineers. Full use is being made of state and county road experience with local soil types. The objective is to supplement, not replace soil investigations as presently made by state highway engineers, and especially to enable county road engineers to get more value from their practical experience.

4. Application of the WASHO Test Data to Washington Roads

The test road being constructed at Malad, Idaho, under the auspices of the

Western Association of State Highway Officials, will provide invaluable information on the relationship between load, road, and subgrade. For the people of Washington to get maximum return from their investment at Malad, it is necessary that the Idaho test data be interpreted in terms of Washington climate, soils, and traffic before being applied to the roads and highways of Washington. All soil test data on file at the Material Testing Laboratory of the State Highway Department were microfilmed and segregated according to regional soil classes. Some general conclusions as to relative needs for base course thickness in various parts of the state were postulated. Snow, rain, temperature, and frost penetration data have been collected from local, state, and federal sources. The application of Malad findings in specific regions of the state should yield definite relationships between load, road, and subgrade when data for adequate comparison between the road site and the test site has been made available.

5. Feasibility of Toll Roads in Washington

The increasing density of traffic on main highways creates congestion, which in turn slows traffic and causes accidents. When traffic volume becomes very high, expensive standards of highway construction become imperative. When existing user taxes are insufficient to finance such facilities there is an increasing national tendency to charge tolls as a method of obtaining needed construction which could not be afforded otherwise. The conditions which justify this procedure, and the repercussions on local roads, and on the balance of the highway system, demand careful analyses in the individual states. Experience with toll roads in the East has been sufficient to provide some general rules regarding the traffic density needed to justify toll roads, and also the amount of traffic generated by freeway construction. It was necessary to modify Eastern conclusions to correspond with conditions in the Pacific Northwest where the rate of car ownership, the use of competing means of transportation, the number of alternate routes, the length of the average trip, and the overall travel pattern are apt to differ from those prevailing along the Atlantic Coast.

6. County Gas Tax Allocation

The 1953 Legislature directed that a study be made of the allocation of the counties' share of the state-collected motor-fuel taxes among the several counties. This directive was the outgrowth of the request of the Washington State Association of County Commissioners because of the feeling by some counties that the present plan for distribution of these funds is, in part, inequitable. The basic consideration in formulating a plan for the distribution of county road funds is the relative need of the several counties for such financial support. This involves investigation of the cost of providing and maintaining an appropriate county road system in each county, and then incorporating the main cost factors in a factual and practicable formula for apportioning the available revenues.

7. De-Grading Aggregate Stud

Certain crushed-rock aggregates in several areas of the State of Washington which pass all standard laboratory tests for satisfactory asphalt-base aggregate, break down into plastic fines or silty clay under average traffic conditions. Study is underway to determine (1) why these aggregates break down, (2) what kind of preliminary routine test can be developed to identify them, and (3) how they may be treated so that they can be used satisfactorily for road construction.

8. Highway Cost Allocation

Legislators and highway administrators face no other problem so pressing as that of adequate and equitable financing for the roads and streets they administer and build. Through the years the bases for road financing have evolved from solely governmental responsibility to the present shared responsibility of the government, property owner and user. With the advent of new types of roads such as the urban expressway, need has developed for a scientific, factual study to determine the equitable share of the total road costs of a state that should be borne by each of the sharing groups. Recognizing this problem, the 1953 Legislature directed that a study be made of "motor vehicle taxation including the assignment of total costs among property owners, general taxpayers and highway users." Numerous theories have been proposed for allocating the costs of highways. A board of nationally known consultants has outlined the scope and needed areas of investigation required for a comprehensive study that would spell out the effects of the several theories of highway cost allocation on the economy of the state.

In all these efforts there has been a public service of greater import than may be apparent at first glance. The Council has never felt that a problem can be correctly analyzed in a vacuum. The solution of a problem must include its public acceptance. The nature of a highway problem is comprehensive—it involves people, and the effect upon people is a part of the problem. The composition of the Washington State Council for Highway Research is admirably contrived to view road problems in a practical and humanistic setting, and the reports of the Council should, and do, receive general acceptance because the group is so broadly representative.

The institutions of higher learning and the other research institutions in the state, together constitute one of the greater natural resources of the State of Washington. The Council's constant effort is to exploit this natural resource for public benefit. The dividends from the investment have been great, and will grow larger in years to come.

HIGHWAYS: OUR RESPONSIBILITY TODAY AND TOMORROW

JULIA BUTLER HANSEN

It is a great honor and distinct privilege to talk with you tonight. I am not quite sure why you have so honored me. My fellow citizens in the State of Washington know that I am not an orator nor an engineering authority. Undoubtedly you will soon discover these sad facts for yourselves. However, I bring you the greetings of your neighbor, our great State of Washington, and the greetings from the eleven western state members of the Interstate Highway Policy Committee.

When any legislator appears before a group at this stage in the legislative proceedings, that legislator feels a little the worse for wear. Undoubtedly your State of Oregon is like our state—in the midst of severe legislative struggles with highway problems, schools, appropriations, and revenue. Yesterday we heard requests for some 80 miles of road extensions to our state highway system which, I may add, do not have the enthusiastic support of our Highway Commission and Mr. Bugge. These presentations of road desires from all sections of our state before a legislative committee, however, are indicative of the tremendous desire for the immediate construction and development of highways.

Last evening bridges over part of the waterways which form a large part of our state's transportation system were discussed. If we could only leave the problems at the state level they might be relatively easy to solve. However, I find myself during this particular session using all my spare moments to assist and to extricate my own two counties of the legislative district I represent from county road revenue difficulties brought on by the afternoon speaker's "unbiased" study of the county gas tax allocations. It was, undoubtedly, an "unbiased" report, for only a college professor would have the courage to chop the revenue belonging to the counties of the chairman of the House Highways Committee $270,000 to $280,000 per year to $80,000 per year. The professor is a philosopher, a scientist, and I am not sure that he does not occupy some quarter in an ivory tower—which reminds me of a small joke in our state that has come about through the years.

Not long after Bill Bugge, our popular director of highways, came back to Washington to direct our expanded program, he was confronted by irate legislators who had suffered from unexpanded programs of past bienniums. His favorite reply to all requests in the legislature was, "I'll do a study." At this moment I would almost like to have Mr. Bugge say to Mr. Riedesel, "Let's do another study of Mrs. Hansen's gasoline tax problems."

I do want to point out to you, however, that our state some years ago did become increasingly aware of the necessity for highway programing and public planning. We recognized that we must have (1) a better public understanding of the highway program, and (2) the needs, development, and revenue for its development. The legislature of the State of Washington, like that of the State of Oregon, proceeded to do something about this. We recognized the fact that engineers and departments never could secure the legislation necessary to build the kind of system of highways that would, in turn, build its future without a sound basis of fact. Thus we approached this problem on the research level.

Studies have been conducted and are being conducted in our state on all facets of the compacts program. This research and study would have been lost had they not been presented during their development to the people of our state. Thus it was that the Joint Fact-Finding Committee of the State of Washington, on which I have had the pleasure of serving as a member since 1947, developed first the needs study. It laid out a long-range area of planning with the integration of cities, counties, and state into an orderly legislative pattern.

Not all the things recommended have yet been accomplished, but each biennium finds us a little closer. Along with the long-range planning of the needs and the policies were the ever recurring problems of revenue. We still are at work on these problems. Just last week there was about to be introduced in our House a measure which would have meant a loss to the Motor Vehicle Fund of some $600,000 during the biennium. At one time our legislature might have considered this without any relationship to the meaning of the loss of this revenue for the state system. This is not the case today. Sponsors of the bill, I notice, are proceeding rather cautiously, and I doubt legislative approval.

As the years have proceeded, this same Legislative Joint Fact-Finding Committee urged the enactment of the Washington State Highway Commission Act.

Realizing that long-range management belonged of necessity with the long-range highway program, Washington turned toward a bonding program to solve its critical needs, realizing the traffic pattern must be better and these revenues which the increased facilities would yield would pay in the long run for this program.

Supplemental to this, we enacted limited access, a most difficult step in our state, and this session we are implementing our limited-access law. There is less storm today about amending this law than anyone could possibly have foreseen six years ago.

Because our state borders Puget Sound, and the waterways of Puget Sound are a part of the travel pattern, the Joint Fact-Finding Committee cooperated with the Highway Department, and later the Commission, to establish a program of cross-sound bridging. Legislation before this current session has further integrated the ferry and bridge programs of the future.

Because of tremendous public interest in highways and the tremendous desire of people in all states to secure roads on state systems, Washington proceeded with an orderly highway classification study, endeavoring to show to the legislators of the future the state's interest in these roads. This probably saved the State of Washington over a million dollars in the last biennium. It will save the state in this biennium perhaps another million.

This classification study must be implemented eventually to its fullest degree by legislation, but this, again, will take public understanding of the program. Each person in each county of our state must understand why roads and which roads are important to the development of the state.

Washington has proceeded on toll-road thinking. Pending before the legislature is a bill for the Tacoma-Everett Tollway. Also before this legislature, as I mentioned before, is a county gasoline tax reallocation.

Our State Highway Commission has just recently completed its 10-year program. The Highway Benefit Study, under the direction of the Washington Highway Research Council, with Mr. Hennes and the other members of the council who work on this project, is midway. A program of renumbering our state highways and continuing county gasoline tax studies goes on.

These are the things that a legislature, working in cooperation with a state highway commission, other administrative branches of our government, and the public have developed for our state's highway welfare.

I want to pause here just a minute to talk about John Q. Public and our highway problems, for it is he that any legislator, because of the processes of democracy, must work with all the time. Public support is essential to any action by a governmental agency. Without that support and interest no program, regardless of how vital it is to the public interest, can survive or develop. Thus, for effective action to meet this challenging highway problem of today and tomorrow, it is necessary that the public be alerted to the need for a sustained program of continuous betterment to its highway system.

Great strides have been made. Newspapers, trades associations, and groups throughout the country have done much, but these educational campaigns can easily lose steam. It is necessary that we make certain that every member of the public knows fully the advantages of good highways and the benefits for himself and his Nation derived from those highways.

What can we bring home to the people of our states? First, the reduction of accidents. Automobile accidents cause an appalling loss of life and many of these accidents can be attributed to the fact that our roads are crowded and the capacity is exceeded. In 1953 a total of 38,300 persons were killed in vehicle accidents in this country. Studies by the Bureau of Public Roads show that the fatality rate is 2.9 deaths per 100 million vehicle miles on highways built to standards prescribed for the interstate system, while all other roads in the same area with similar traffic show the death rate to be between eight and ten per 100 million vehicle miles. These figures indicate that our fatalities can be reduced by better highways.

Another study by the Bureau shows that there were 179 accidents per 100 million vehicle miles on roads where access was fully controlled, on other roads where access was only partially controlled there were 258 accidents, and on roads where there was no access control there were 425. Better highways seem to mean that more people may live longer. This is a story for the people.

In the State of Washington we have an excellent example of a highway improvement which has resulted in a reduction of accidents. Along Fort Lewis on U.S. 99, about four miles of new highway were opened to traffic in the summer of last year. During the three months—July, August, and September of 1953, there were a total of 48 accidents with 21 injuries. During the same three months in 1954, with heavier traffic and after the new highway opened, there were 26 accidents with only 9 injuries. This is an outstanding example of what better highways can do to decrease accidents.

Accidents, of course, are responsible for the necessity of insurance premiums. The more accidents the higher the premiums. In 1952 the vehicle owners in this country paid about $3,650,000,000 in insurance premiums. This money would go a long way in building more highways or better schools or hospitals. There is no reason why this insurance premium figure can't be reduced, and why that money can't be used for these purposes.

This accident problem and its effect is only one of the stories that may be used to demonstrate to the public that better highways pay off in better living. There are many more.

One of the many problems in highway administration is weight control. It is a fact that anything can be broken, and a highway is no exception. If enough weight is placed on a particular spot on a highway, that spot will break. Even if a lesser weight is applied enough times at that particular spot, that spot will fail in time. The problem, of course, is to seek some balance in the weight of vehicles so that the weight and the frequency of those weights do not prove to be factors which cause a highway section to wear out before its reasonable life expectancy has been reached.

The act of controlling weight then is not a punitive measure taken by a state agency to discriminate against a particular transportation agency. The state is not being anti-truck or anti-progress or anti-anything when it checks on vehicle weights. The state is protecting the people's investment in highways, and the investment of the heavy vehicles is also being protected when enforcement of weight restrictions takes place.

Of course highway engineers can build highways which will sustain any load you want to put on them. However, building those highways for those bigger loads costs money, and the bigger the load the highway is designed to carry, the more money that has to be scraped together to build that highway.

Highway design in most states is geared to certain weight limits. We must hold heavy vehicles to legal limits so that investment in the highways being built today will be protected and our highways will not wear out before their expected life length has been reached.

We Americans use our highways more than any other people in the world. In these 48 states, we have over three-fourths of the passenger cars registered in the world, and nearly half the trucks, although our population is less than 6% of the world's total. We build over 65% of the vehicles produced in the world.

Millions of school children ride to and from school over county roads, city streets, and state highways. Those people working in offices, farms, and factories of our nation use highways to ride to and from their work. Trucks bring groceries to our doors.

Four out of every five farms are well served by all-weather roads. With but few exceptions, crops can be hauled and supplies brought in in complete safety throughout the year in the most remote areas. Uncle Sam delivers our mail to almost every door—no matter how rural and how remote the home. Vacation travel would not exist as it does without a modern highway system.

Freight moves everywhere and moves to supply human demands. Good transportation service is vital to increases in standards of living and to a greater enjoyment of leisure hours.

Now, a quick look at a few facts on highway transportation. We find that almost 15% of the workers in this country have a job directly connected with highway transportation. There are about 900,000 workers in motor vehicle and tire factories and 600,000 in closely related industries. Over 280,000 persons work for highway departments in the country and almost 300,000 work in service stations. Over 5¼ million men drive trucks and buses, and nearly 2 million work at selling vehicles and servicing them. Add them up and we find that almost 10 million jobs exist in the highway transportation industry.

Seventeen per cent of the retail, wholesale, and service businesses in the country are connected with motor vehicles. Sales of motor vehicle and accessory dealers amount to almost $30 billion annually. Payrolls in the vehicle manufacturing industry alone reach almost $3 billion.

With so much of the nation's working force dependent upon a dynamic highway transportation system, it is in America's interest to vigorously continue building a better highway system.

This is a story for the people, too. Translated into simple English, it means that because of good transportation we Americans enjoy high living standards and a diversity of goods and services. Goods move thousands of miles without border inspections and without import taxes imposed in any of the 48 states, making it possible for our people to specialize in the jobs which suit their talents best, and in those jobs which geographical and climatic conditions make most suitable.

Import restrictions in each of these states do not exist, or we would not be able to do this. Each little state would be a tight economic entity in itself, and our high standards would vanish.

Truck and bus transportation is a vital part of the transportation system. Reciprocal relations between states which do not recognize these fundamental economic facts of life can do serious harm to the transportation system of the country and to our goal of higher living standards.

This reciprocity problem has not been easy. Only by cooperative comprehensive study and an attempt to reach the basic facts, and by a willingness of all the states to work together can it be worked out.

Our Western Interstate Committee has taken the lead in this problem of reciprocity in the West, and perhaps a real contribution has been made toward solving this very fundamental problem. Before each legislature is a proposal which guarantees the state's sovereignty as to type of tax, but reciprocity for full use.

President Eisenhower has perhaps summed up the universal desire of Americans to better their way of life with highways by the creation of the Clay Committee. Mr. Baldock, your outstanding and capable highway engineer of Oregon, gave you the details earlier, and it would be most presumptuous on my part to attempt to add anything to this discussion. However, I would like to point out that this program of the Federal Government can go only as far and as fast as our states and the people of our states work to build it. It is not only necessary that you engineers who understand the design, control, construction, and maintenance of our public highway systems participate in developing this highway plan, but it should enter into the thinking of every man, woman, and child. It is a joint adventure of governmental planning and management. There must be no temptation to convert to personal gain the future of highways, and we can be grateful for the lessons the past has given us. But build wisely, solidly, and with vision for the future.

I am going to repeat something I said a long time ago and which Mr. Bugge has heard before. One spring day I was in Eastern Washington at that particularly peaceful spot near the Walla Walla River under the wide blue sky of Washington, and I looked across to the Blue Mountains. I stood within the little space where Marcus Whitman's blacksmith shop was and where he tended the broken wagons and forged out new shoes for the weary oxen. As I stood there I saluted that first wagon trail maker who passed our way and began the first American settlement of our state and contributed to the Christian development of your own State of Oregon.

As I walked away, I glimpsed the long future where our great highways roll across the sage and across those greening spaces of land under development in the Columbia Basin area where man's dream of a harnessed river is serving the people of the West, and I was proud and grateful that the people of our West have accepted the challenge of those early pioneers by bridging the waters of this river and building roads that will send us into the future of our two states and the nation.

All persons having some small part in understanding and building these roads must remember that they not only build a transportation system of concrete and steel which will strengthen the economic structure of our states and our nation, but they also forge powerful links in the orderly development and progress of the world. They have contributed to better communication, and thus better understanding. With each opening road, each closer grasp of a neighbor's hand, mankind moves upon the greatest highway dream of all—security that leads to peace among us all.

Panel Discussion on

The Use of Modern Paving Machines for Asphaltic Concrete Paving

O. C. JESSUP:

First, I will endeavor to treat the subject of the bituminous paver that does the paving job after the mix has been hauled out from a central mixing plant or hot plant. I am referring to a machine that has enough power and traction to push the truck along while it is dumping the mix into the receiving hopper of the paver. The present bituminous paving machines that spread the material arriving from the central mixing or hot plant, lay a compact, level course of bituminous mix; spreading the material evenly, compacting it to a uniform density, and automatically leveling it. Crown and thickness are easily and accurately controlled.

A screed heater is provided on the machine. This facilitates the laying of cold mixes, maintains screed temperatures while working in cold weather, and eliminates scuffing during laying of both hot and cold mixes. An automatic electric ignition system is used on all machines. The self-propelled pavers assure greater accuracy, a smoother course, and better joints.

Paving speeds vary somewhat due to conditions, but generally they pave from about 8 feet up to a maximum of about 60 feet per minute. Relative to capacities, the larger machines now on the market will put down approximately 200 tons per hour of pavement 2 inches thick. The tons per hour, however, are governed by the thickness of the pavement and type of aggregate being used. In certain parts of eastern Oregon, cinders are sometimes used and the capacities in tons per hour would be lower due to the lighter density of the material.

The modern bituminous paver lays any asphaltic material, hot or cold, in widths from 8 to 14 feet, and in thicknesses from almost zero inches up to approximately 10 inches. In most instances, however, as you already know, a certain thickness is prescribed by the engineer.

There are a number of smaller paving machines on the market that are towed by a truck. They have a receiving hopper, an agitator, and a drag-type hinged plate behind the strike-off gate. This machine can be used on hot mix asphaltic concrete and other free-flowing materials without the agitator. This type of paver, however, is for small jobs such as driveways, et cetera.

There is another type of machine being sold quite extensively which can be used either as a hot or a cold mix machine. This machine mixes the material and lays it out on the road ready for rolling. The aggregate, either hot or cold, is dumped into a receiving hopper by a truck and then moved forward from the hopper into a bucket line by means of a bar conveyor or belt. The bucket line discharges the material into a surge bin. The aggregate is calibrated into the pug mixer from the surge hopper. The asphalt is metered into the pug mixer through spray nozzles. The mixed material is then discharged out of the continuous mixer in front of a screw. Back of the screw is the strike-off which is adjustable to various heights from ½ to 7 inches. On either side of the strike-off and fastened to it are two 25-foot runners which tend to give a very good correction and take out irregularities. This machine has a capacity of 100 to 120 tons per hour.

Another method of constructing a bituminous road is known as the "road-mix" method. There are several different methods of blending aggregates and binder. These are with a grader or blade mixing, mechanical mixing, and travel plant mixing. Blade mixing is just what the name implies—mixing by use of a patrol grader. Mechanical mixing is accomplished through agitation of the aggregate and bituminous material by some form of tines or paddles attached to a rotating shaft. The travel mix plant picks up the aggregate out of windrows, elevates it to a hopper, and the material is calibrated into a mixer. The bitumen is metered into the mixer. The mix is then discharged into a windrow at the rear of the machine.

In conclusion, a paving machine should lay specified material smoothly and well enough to give long lasting life, with good riding qualities.

GEORGE HAMSON:

I would like to speak just briefly about Mr. Jessup's remarks on the use of modern paving machines. I thought he covered the finishing very adequately, and also the different methods of finishing.

Specifications for finishing are quite similar, not only in state highway departments but in bureaus such as the Bureau of Roads. The finishers should be self-propelled and should have some means of screeding or striking off the material. There is at least one finisher which uses a combination of these methods in laying down the mat. It is one of the most highly acceptable finishers on the market today. The reason I am bringing this up at this time is that I am going to discuss something presently which does have some bearing on the type of finisher that is being used.

We are about to get started on the final phase of asphaltic concrete construction. It is very simply described, but if it is not done correctly it is gone forever and it has to be torn out and done over again. This operation is called "compacting" or "compaction." It can make or break a good job in every other operation or step. It is the final finish—the operator can either ruin the job completely or he can sometimes salvage it.

I don't think it is necessary to go into detailed roller specifications at this time. Manuals have been prepared by various contracting agencies which set out the detailed specifications and are available to the public. However, a few types of rollers are generally used in asphalt finishing. We have the tandem type with the full width compression roll, or the three-wheel type. I believe in the picture you saw a few minutes ago both types were being used.

What is a roller? It consists of inanimate pieces of steel, castings, gears, and a power plant. Generally speaking, the combined weight of all these reaches the weight specifications set by the contracting agency. The rollers must be in good mechanical condition, mainly in connection with reversing directions so there will be no slippage, skidding, or jerking of the fresh hot mat, which would tend to damage it, and there must be water to keep the rolls dampened so they will not pick up or displace the fresh surface. There are no gages, however, and there is nothing on a roller to tell the operator, inspector, or engineer on the job when to go to work or when to stop. On asphalt plants, either continuous mixed plants, asphalt batch plants, or others, there are all types of visual controls. The operator can tell by gages what he has to do, but on a roller the operator is dependent on his own ability. It will go when, where, and how he makes it go—no more no less.

There is virtually no set way to determine except by experience just when the timing of the roller pass is absolutely correct, nor when it has been rolled enough. This takes into consideration the operator, the engineer in charge of the project, and the inspector in charge.

Many factors enter into this process, but we will cover just a few of them here.

1. Aggregate gradation—percentage of fines, etc.
2. Type of bitumen used—dependent upon specific gravity and weights involved.
3. Percentage of bitumen in mix.
4. Subbase condition—is it entirely solid or does it have a tendency to be a little spongy.
5. Atmospheric temperature.
6. Depth of the mat and amount of pressure to get down.
7. Type of finisher used in paving operation.

Some of these we can control, others we cannot, and we have to second guess just a little.

At this particular point I will discuss the most controversial subject in the entire paving operation. I would like to say that the following is my own personal opinion and does not necessarily reflect the ideas of my company or the manufacturers who are backing me.

The initial depth compaction pass should be taken as near the finishing machine as possible, and preferably with the lighter specification roller. It should be taken on a single pass basis, paying little attention to tire marks. As long as the material does not pick up or displace by squeezing action or sliding, everything is satisfactory.

Some may wonder if we have forgotten the surface, but remember it is absolutely necessary to compact the entire depth of the material of the lift, and only the surface comes in actual contact with the compression roll. This means there is plenty of time to take care of that on top.

In taking the intitial depth compaction pass it is well to note that it should be started from the outside edge of the roadbed and rolled progressively toward the center of the road, taking care that the overlap on each pass is approximately one-third to one-half the width of the roller. It also should always be done parallel to the roadway's surface; that is, parallel to the centerline. The main exception to this rule is that on super-elevated curves the procedure should be reversed to the extent that the rolling should be done progressively up the super, disregarding the standard practice of rolling parallel to the centerline.

No parallel roller passes should be halted evenly across the roadbed surface. Each individual pass should be longer or shorter, as the case may be, to assist the operator in crossing the mat to his next position. He goes across the mat in a long diagonal, which enables him to cut off the ends of each parallel pass as he goes, leaving a diagonal of rolled and unrolled material—a good clean mark.

After the initial rolling is completed, the next obvious step is to finish rolling. Here again only the operator and engineers in charge can give you the answer. You cannot find it in any book. It does little or no good to continue rolling a mat before or after the time that all factors involved are compatible. By that I mean the heat has to be correct because if it is not there is a tendency for the mat to rise again after it has been passed over with the compression roller. We can now go ahead with the roller, compress the mat and gradually punch it down to the desired percentage of compaction and it will stay there. In this process all wheel marks are removed, and the resulting surface should be acceptable to the most critical engineer.

Care must be taken in this operation so that the desired crown in the road surface is not over-rolled and lost. This is very important because the finisher and the crew ahead of you have gone to a lot of trouble to put in the crown.

Excessive rolling is nearly as dangerous as under rolling, because this can cause checking or hairline cracks in the finished mat. Quite often this can be eliminated and the paving saved by finish rolling with a lighter specification roller, which will tend to heal up the cracks without further compaction. It also tends to make the surface watertight, but this would be possible only if there is enough heat left in the mat.

We now come to rolling of joints. This is quite similar to the general practice of rolling a flat mat except that in cold joints you should poke down the hot material just as fast as you can get it against the cold joint, and roll it immediately. Actually, it would be well to have the front wheel of the roller tight to the finisher at all times. The objective here would be to use the cold mat as a guide joint, overlap whatever is required (from 6 inches to a foot or more), and allow the hot fresh mix to lie in against the cold joint and actually weld and bond itself into a smooth, watertight joint.

If a hot joint is to be made, such as two finishers working reasonably close in tandem, then the joint area of the finisher in the lead would be left unrolled approximately 6 inches from the edge. The following finisher would match this joint with the next layer of mat; that is, alongside of it. On the initial roller pass, the depth compaction pass of the roller behind the second finisher would catch the joint. I believe this was shown in the film on the Oklahoma Turnpike. They used hot joints practically all the way. This would either take two finishers or a considerable amount of moving around with one.

Patching should be accomplished in about the same manner. If it is necessary to remove any pieces from a damaged mat, the cut should be made as square-edged as possible. The general overall dimension in the cut is not important, but the vertical cut in the existing mat should be rolled in exactly the same number of steps.

In closing I would like to say that there is no book in which you can find information about when and when not to roll. It has to be done by the operator and inspector on the job from practical experience. There are too many factors involved that are not standard.

Discussion:

COMMENT: In the discussions we have heard here in regard to pavement laying and related subjects, I have noticed a lack of comment on the use of pneumatic rollers. I am of the opinion that they have a very important place in certain types of work. I am wondering if Mr. Hamson or anyone in the audience who might have seen them in use have any comments to make. I don't believe they are being used in the state of Oregon.

GEORGE HAMSON: I deliberately bypassed the use of pneumatic-tired rollers in the industry, but their use is definitely coming to the front. However, they have not been used very much, particularly in the Northwest. Experimentation has been carried on and the pneumatic-tired equipment is available to the contractor, but most of the state highway specifications at present do not require their use, nor do they prohibit it. It is clearly specified, however, that you will use tandem rollers, taking into consideration that they mean steel wheels and three-legged rollers, but with no mention of pneumatic tires. I think we are going to find in the very near future that the specifications will be revised to include them because it has been proven in the field, on other types of mats, and on base construction that use of pneumatic tires will give greater compaction with less traffic compaction after the road has been turned over to open traffic.

QUESTION: You made the statement that you preferred the lighter roller for the breakdown roller immediately behind the spreader. I am wondering what your reasons are for that.

ANSWER: There are probably a lot of opinions on this because it is a highly controversial subject, as I mentioned previously. It is my personal opinion that by using a lighter roller and by working behind a certain type of finisher, you can get on it very quickly because it has a certain amount of compaction behind it. It is not to be construed that it is a compaction of roller type, but it has already stabilized the mat and getting on it quickly behind the finisher with the lighter type roller, you can get a little better breakdown. A big or heavy roller can be used within reason at the same period of time. I feel, however, that you can roll in closer and get a little better depth compaction with the lighter roller on the initial breakdown. On an overlap of one-third of the roll shell, I would recommend about a one-half, so that you are actually making a two-pass proposition. It should be done quickly and the roller cleared of it immediately.

QUESTION: What do you classify as a lighter weight?

ANSWER: This is entirely up to the contracting agent. They generally specify two weights of rollers to be used on a project. The highway department here in Oregon specifies that you shall have at least one roller of six tons, and if you have only one roller then you must have one of ten tons. If you have two, you should then have one ten and one six ton. This may vary with different contracting agencies. I am not sure just what the state of Washington requires. Personally, I think that a six ton is sufficient on the initial breakdown *if* you take it in close to the finisher. If you cannot get in close due to the type of finisher being used, that is another problem.

THE ROLE OF INSPECTOR

OSCAR A. WHITE

In order to define the role of the inspector, it would seem necessary to answer only one question: Why do we have inspection? The answer to this is obvious and simple: To obtain quality materials and products.

The interest lies in how the inspector achieves his role, rather than a definition of that role. This changes the subject from "Why do we have inspection?" to "How do we inspect?" We want to know what kind of a character the inspector is, what he must know, what he does, and how he does it.

An inspector must be nosey. Perhaps a better word is inquisitive. Yet he does not act as a policeman or prosecuting attorney. He must know what is going on, but in no sense does he try to find fault merely to show his authority.

It must be impressed on the contractor that inspection is a cooperative process, and that a specified product at the lowest cost is the general aim. Frequently the inspector can suggest changes in procedure that will increase production and still obtain the required quality product. We are well aware that any production increase we can achieve will gradually show up in reduced bids on future projects.

An example of how not to inspect was brought out quite clearly last summer. The inspector had a good educational background, he was highly intelligent, and he knew the specifications from cover to cover. His only deficiency was a lack of experience in asphaltic concrete inspection. He was left with a job mix and told to hold closely to that design. The plant was of the continuous flow or volumetric type. The following week when I arrived, the superintendent and the inspector were at each other's throats. The inspector showed me the week's plant analysis, and he had kept the mix as directed. The trouble was that there was a deficiency of one size aggregate in the stockpile. In order to get a sufficient amount of that size, an excess of a second size was created and had to be rejected out of the bin overflow. The inspector began to get too much of the excess size in the mix and cut the flow from that bin. This caused excessive buildup, with consequent overflow into the other two bins, as well as out the reject chute. So, the inspector further reduced the flow of the excess size to the mixer. Eventually an equilibrium was reached, but the production was less than half capacity. The remedy, of course, was to raise the deficiency size openings rather than close the excess size opening. This incident showed clearly that an inspector must know what is going on inside the plant. A knowledge of the mix proportions is not sufficient, however important such knowledge is.

An inspector must have a temperament somewhere between that of a research man and a routine worker. Every new job requires a certain amount of experimentation before a satisfactory mix is obtained. Preliminary tests by the laboratory on samples from the stockpile are well and good. Such tests will provide a reference mix for the material in question, but the preliminary laboratory mix is seldom, if ever, the exact mix used. This is primarily because the plant bins are never clean. That is; each bin contains material of a size other than that which the bin is theoretically supposed to contain. Consequently, the laboratory mix and the job mix do not coincide. Also, there is always the probability that the laboratory sample does not correctly represent the stockpile.

The previous job mix also is considered only as a reference point, regardless of how satisfactory it may have been. A paving plant seldom screens aggregate from two different sources the same way. A No. 8 screen that thoroughly cleans out all smaller sizes from one aggregate may have as much as 20% override on another aggregate. This may be due to particle shape, condensed or trapped steam, or possibly to the cohesive properties of the aggregate dust. Moreover, particle shape has a definite bearing on the physical characteristics of the final asphaltic concrete. Aggregate from two different sources may require entirely different mix proportions of fine sand, coarse aggregate, and asphalt content to obtain the same desired flexibility and void content. The plant inspector must experiment using the known factors that are at his command as a starting point. From preliminary laboratory tests, from his bin size analysis, and his final product analysis he can make changes in the mix until he obtains the product he wants.

At the same time the plant inspector must cooperate with the street inspector, who has his own problems of laying, compacting, and making joints. I would suggest that these two inspectors be interchangeable. In that way each would know the problems of the other and each would be better able to plan for those problems.

Certain types of mixes can be rolled indefinitely without harm, while other types will crack and crumble with continued rolling. Also, certain mixes will compact more than others. Knowledge of these differences is essential to the street inspector in his work. Even with this knowledge of different mixtures the street inspector must do a certain amount of experimenting, with the cooperation of the plant inspector, to obtain the most durable and smoothest pavement possible.

I have given in more or less general form the problems which confront both the street and plant inspector. Now, just exactly what do they do?

The plant inspector should arrive at the job a day before production begins. He should go over the plant thoroughly; checking screen sizes and their condition; examining bins, their overflow provision and the height of partitions; and checking scales for free movement and accuracy. He should go over the stockpiles and estimate the moisture content. If moisture content is high, vibrator types of feeders will be required in the feed tunnel.

Prior to starting the plant, the inspector must set a trial mix based on laboratory tests of the material and previous operation of that particular plant. When the plant starts production, samples are taken from each bin from an opening provided for that purpose. While these samples are being screened with a motor driven shaker, the inspector takes a sample of the finished asphaltic concrete from which he extracts the asphalt with solvent. The remainder is dried, weighed, and screened. These tests take from 2 to 3 hours of intermittent attention. From the analysis of the finished product the inspector knows what is lacking or what is in excess, and from the bin analysis he knows what to do to remedy the fault. When the plant inspector has made the adjustments he thinks necessary, he should contact the street inspector, and they should observe together the laying and rolling qualities for possible improvements in the mix.

The street inspector is somewhat at a disadvantage. He has to lay what is sent out to him or reject the whole load. Before suggesting changes in the mix, however, he checks the efficiency of the equipment where the trouble exists. The screed and tamper may be out of adjustment or worn out, the roller may be inefficient in some manner. Also, the street inspector must know the peculiarities of his spreading machine. He must know the length of lag between the time he moves the screed screw and when it takes effect. This knowledge will make the difference between built-in bumps and a smooth pavement. He should control the spreader speed to conform to the plant production. The more continuous the spreader operation, the more uniform the job will be.

Soon after the job starts, the inspector should obtain the density of the compacted pavement. From this value he can calculate the tons per station needed to obtain the required pavement thickness. If, after due consideration, the street inspector is convinced his difficulties begin at the plant, he should so inform the plant inspector.

This cooperation between the two inspectors sounds good in a speech. Due to human personalities, however, the cooperation may turn into verbose animosity, with each thinking the other is an ignorant loafer.

After a day or two of adjustment, the aggregate weights, asphalt content, and temperature are usually such that a well spread and compacted pavement is placed that has the flexibility and non-skid qualities desired. When this condition is obtained, the mix should not be changed. Usually variations in the plant operation and stockpile will straighten themselves out. If not, the fault should be corrected at the source, and not by changing the mix. The latter will only aggravate the trouble.

PORTABLE ASPHALT MIXERS

AL SHURTZ

I would like to speak about portable asphalt mixers strictly in the portable sense—small machines. In the first place there are, as you know, two classes of portable asphalt mixers; the batch type and the continuous type. These can be divided into the hot-mix type and the cold-mix type.

The hot-mix machines will make a heat-activated mix; something between a hot and a cold mix. There is food for thought, I believe, in the consideration that patching of roads may be accomplished with a mix that actually has the advantages of both the hot mix and the cold mix. Some of the advantages it has in common with the cold mix are:

1. It can be prepared with light, high-capacity equipment. (When I speak of high capacity, I mean high capacity only for patching operations.)

2. Less fuel is used than in hot mixtures.

3. It can be hauled long distances without setting up.

4. It can be placed in a stockpile for later use if it is made from the right type of cutbacks or emulsions to start with.

5. It can be made with damp or wet aggregates.

6. Initial cost and cost of moving the plant is much less than for hot mixtures.

7. Soft asphalts can be used because the temperature is not so high that it will cause the asphalt to run off the stone.

Qualities it has in common with the hot mix are:

1. It can be placed in weather that is adverse. (I don't recommend laying it in a rainstorm, of course, but you can place it in damp weather.)

2. The aggregates are coated with a film of pure bitumen.

3. Mixture is not susceptible to stripping or washing at any time after the mixing operation.

4. Pavement can be rolled immediately when the heat-activated mix is used, and traffic turned on it as soon as it is rolled.

There are several types of small mixers on the market that can make this particular kind of mix of which I have been speaking—something between a hot and a cold mix. The conventional plant, of course, you all understand. It has the drum dryer and generally a pugmill type of mixer into which the stone goes. There it is combined with the asphalt and mixed and discharged either into a truck or directly onto the road.

What I would call a nonconventional plant or machine employs a process of mixing and drying simultaneously in an enclosed pugmill without the presence of oxygen. I would like to speak about these because I believe that at least some of you have not gone into the subject and, therefore, are unfamiliar with them.

The process used is actually one of drying and mixing at the same time. Either torches or a low pressure burner are used to increase the desired temperature of the mixture. At this temperature, the hot gases from the burner mechanically carry the moisture from the mixture. Mixers of this type have a stack which is there for two purposes: (1) for discharging the moisture driven from the stone, and (2) for allowing the volatiles to dissipate so that the machine will be safe and will not blow up if cutbacks are being used.

Heat-activated mixes can be made in both conventional and nonconventional plants. I think it is quite important to keep temperatures down, and I have some reprints here of an article that appeared in an old issue of *Contractors' and Engineers' Monthly* which deals with temperatures of asphalt mixes. Of course the article speaks of conventional plants and large jobs, and even on these they advocate keeping the temperatures down as low as possible.

Discussion:

QUESTION: I would like to ask a question of Mr. Shurtz about his mention of the portable mixer, but first I would like to make a comment.

In patching of outlying areas of Washington or any state, it has been customary to use cold premix and, at certain times of the year, a cold mix will not stay there because it is lumpy and contains a lot of solvents. Personally, I think a hot mix does a much better job. Therefore, we are towing a small portable mixer to these outlying areas and placing the mixture hot.

It has been maintained that wet aggregate is mixed with asphalt without the presence of oxygen. I find that we have never had flashes with MC or RC, but oxygen is there. The mixer is not airtight, so I wonder why you pursue the theory of mixing without the presence of oxygen.

ANSWER: My theory on that agrees with yours. There is oxygen there. On our particular machine we have a blower that actually inducts air, but it brings in only the amount of air needed for combustion, and none is left over for oxidation of the asphalt. I believe that on the little patching machine you have there is a heat inlet and a couple of coil-type burners that are directed into the heat inlet. We get oxygen for combustion of fuel in the burners through the heat inlet. Actually, you are right; there is oxygen at this point, but we have a complete coverage of nonoxidizing gases hovering over the mix and that is what closes off the oxygen, not because the box is airtight. The hot gases hovering over the mix all of the time and doing the heating are essentially oxygen free and inert.

We have run tests, and governmental bodies who are unbiased and interested in the same question have run tests on the machine in this manner: They have put only the aggregate in the hopper of the machine, dropped the aggregate down into the mixing chamber, left it in so many minutes, and brought it to 300 degrees. They then shut off the burner, put in the asphalt, and mixed that for one minute with the hopper gate open. They then put this mix in a pile. They loaded the machine again, poured the asphalt right on top of the wet aggregate, dropped all of it down into the mixer at the same time, and left it until it came to 300 degrees. It was then discharged and put into another pile. They then ran extraction tests on the two piles and actually found that the penetration of the asphalt was reduced less than the one where the hot gases hovering over the mix had kept out the oxygen.

It is not heat that makes asphalt reduce in penetration, it is oxidation. Actually, that is the way they make a blown asphalt—by getting it hot and blowing in oxygen. We conclude, then, that oxygen is kept effectively from the mixture because it is surrounded by spent, inert gases. We believe the mixing chamber does not have to be airtight, because there is actually a slight pressure inside the mixer and leakage is in the other direction.

STREET INSPECTION OF ASPHALTIC TYPE PAVEMENTS

F. N. FINN

As a prefatory remark, the writer would like to state that this article should be considered a report on street inspection as practiced in California. Information and comments contained herein have been obtained from observations on state, county, and federal jobs, and in conversations with state and other highway engineers. Special thanks are due Mr. Vaughn Marker of the California Division of Highways Construction Department, for his cooperation and assistance in providing background information for this article.

The primary function of any street inspector as a representative of any specification-writing agency is to see that the paving mixture is placed in accordance with the plans and specifications. This is an all-inclusive statement and covers a wide range. Essentially, however, this is the final objective.

It is also important to keep in mind that the street inspector does not tell the contractor how he must conduct his job, although he does maintain a constant check of workmanship and procedures regarding requirements of the plans and specifications. To be able to perform this function the inspector should have a good overall understanding of not only the street operation, but also the plant operation, and he should have a good knowledge of the material with which he is working.

It might be of some interest to the reader to know that the majority of street inspectors for the California Division of Highways are in the junior grades. Usually they are young men who have a BS degree and relatively little experience. This is necessitated by the fact that the paving program in this state has been expanding at a rapid pace and men with experience are being promoted to positions of wider responsibility. For his experience the street inspector can and does look to the resident engineer for guidance. However, this is not always the most desirable and expeditious arrangement.

To help compensate for the street inspector's usually abbreviated experience, the California Division of Highways is now preparing a series of strip films to be used for training purposes. At the present time, however, the Division does not have a formal apprentice program for the training of this type of personnel.

The good street inspector has a wide range of items to be checking constantly—in California the emphasis is on equipment condition and equipment use. This means a constant checking on various pieces of equipment to assure that all adjustments have been made, that equipment is in good running condition, and that equipment is not being operated beyond its capacity. It is felt the broom, blade, spreader box, and paving machine are to the street inspector what the hot plant is to the plant inspector. Some of the most important items to check are listed below:

1. *Asphalt distributor*

    a) Tank provided with calibration stick.

    b) Spray nozzles clear and not burred.

    c) Spray bar properly elevated for uniform spray.

2. *Broom*

    a) Bristles not too short.

    b) Adequate power take-off to broom.

3. *Spreader box*

    a) Provision for uniform spreading, either by mechanical means or shape of box and guide baffles.

    b) Capable of adjustments in windrow size to provide for varying widths and depths of spread.

    c) Tires uniformly inflated, preferably at a high tire pressure to reduce up and down movement of box during spreading.

4. *Blade*

a) Blade width 10-foot minimum (usually 12 feet on current jobs).

b) Wheel base 15-foot minimum.

c) Cutting edge bit should not be worn excessively.

d) Suspension system from which blade is hanging should be snug.

e) Positive movement in all controls, particularly those operating blade proper.

f) Tires preferably smooth and at low pressures for spreading plant mix.

5. *Paving machine*

a) With tamper bars.

1) Proper setting on governor in accordance with manufacturer's recommendation, usually 1200 rpm. Primary reason: proper coordination between forward motion of machine and oscillations of tamper bar for uniform tamping of mix.

2) Proper adjustment of tamper bar's lowest most position in accordance with manufacturer's recommendation, usually 1/64 inch below screed. Reason: to obtain effect of bar in pushing down rock and compacting the mix.

3) Proper adjustments of crawler links to compensate for worn bogeys. Reason: prevent rhythmic "humping" of pavement.

4) Condition of tamper bar. Reason: worn tamper bar will not give proper surface texture or compaction.

5) An additional adjustment sometimes recommended in California is to set in a slight crown, approximately ⅛ inch on leading edge of screed. This is accomplished by disconnecting the linkage between the leading and trailing edges of the screed and then raising the leading edge. The result is a slight warpage of the screed, which has been found to improve its ironing characteristics.

b) Oscillating type pavers.

1) Tolerances on all guide rollers. Reason: any play in the screed's guide rollers will tend to create irregularities in the paving surface and possibly cause a "tearing" of the mix due to "digging in" of screed. The two main sets of rollers are those controlling the vertical position of the screed, which are above the screed, and those which control the horizontal position, which are directly behind the screed.

2) Leading edge of screed slightly higher than trailing edge by approximately ⅛ inch. Reason: improve ironing characteristics.

3) Coil springs compressed against screed. Reason: screed will "walk up" on mix if springs are not resisting this action.

4) Pins, bushings, bearings, and gears from power take-off to screed must be snug. Reason: possible hesitation in the screed during reversing of directions while the machine is still moving forward is apt to cause a variation in the amount of material being spread. Experience on California jobs indicates proper forward speed to be 30 to 35 feet per minute with 85 to 90 oscillations of screed.

5) Means for keeping rear rollers clean. Reason: rollers more apt to pick up hot mix.

These are not all of the items concerning the lay-down equipment that should be of concern to the street inspector. They do represent, however, some of the less obvious yet most important items with which street inspectors should be familiar. The importance of an overall check of equipment cannot be over emphasized in the requirements for good street inspection.

Preparation of the base is important. The street inspector should inspect the base before any treatment or surfacing is applied to assure himself that the base is well compacted to a true cross section. After brooming has been completed, he should check that all loose materials have been removed. General practice in California is to apply an asphalt prime coat of SC 1 or 2 after brooming.

The inspector should check uniformity of coverage of prime coat. There is no specific limit as to how far the prime can get ahead of spreading the asphaltic mix. However, the surface should be clean and the prime well penetrated prior to actual spreading of mix. In the event that excessive amounts of prime remain on the surface, a sand blotter may be used to take up the excess.

In California the plant mix is usually placed in two courses; namely, the leveling course, which may be placed to a maximum depth of 2 inches, and the surface course, which may be placed to a maximum depth of 2 inches.

The leveling course is placed by means of some type of spreader and blade; the surface course is placed by a mechanical paving machine.

The two most important reasons for spreading the leveling course with a blade are (1) to take advantage of the long wheel base to eliminate base irregularities, and (2) to provide a surface texture to which the surface course may adhere.

There is no fixed policy relative to the use of a tack coat (or paint binder) between courses. The decision as to its use is made depending upon the specific circumstances on each job. The street inspector is cautioned to not allow the contractor to use asphalt in excessive amounts. A slippage plane may be created due to "over lubrication," which will have essentially the same effect on the surface as no tack coat. Eventual "bleeding" is another result of over asphalting between courses. From 0.05 gallon per square yard to 0.10 gallon per square yard is generally sufficient for the tack coat.

In addition to the items already discussed, the inspector is expected to make continuous checks on the mix during actual placement. Such items as quantities spread per station, depth of spread, and surface texture are important.

Also important, but more difficult to control, is mix temperature. A fundamental rule of the California Division of Highways, for instance, is to maintain temperatures as low as possible compatible with good mixing and good placing conditions. Allowable maximum temperatures as established by this State's Standard Specifications are usually more than adequate to meet these requirements. Good coordination between plant and street is required to obtain the best temperature.

On the street the inspector should be encouraged to consult with the blade operator, the paving machine operator, and the roller operator to assist them in determining the best temperature. The problem is to know how low a temperature is permissible and still obtain adequate compaction. There is no substitute for experience regarding this item. One possible rule, however, is that the mix should be hot enough that on the initial rolling or "breakdown," moderate roller marks are made by the roller without causing transverse cracking.

In spreading the leveling course, no surface tolerances are specified by the California Division of Highways. However, the specifications do state that . . . "The finished leveling course shall be thoroughly compacted and true to the required grade and cross section." A good leveling course is mandatory for a good surface course. For this reason the inspector must be as critical of the leveling operation as the subsequent surface operation regarding overall smoothness.

In checking the leveling course, the street inspector should consider the "string line" technique for checking between "blue" tops. Very often blade operators are concentrating on meeting the grade requirements established by the blue tops and will tend to pick up extra material between these points. Stretching a "string line" will help to show if there are any long dips in the leveling course. Usually this seemingly gradual dip will not be noticed on a road until relatively high speeds are attained, at which time it resembles riding an ocean wave.

Normal procedure for placing the leveling course is to spread only that amount that can be covered in the following day's operation. Following this rule will tend to minimize the amount of dirt which will accumulate between courses and will, thereby, help establish an adequate bond between courses. There are circumstances that will sometimes require modifications of this procedure. In northern California for instance, where rain is a constant threat and, in the latter part of the season when even snow flurries are a possibility, engineers will sometimes place the entire leveling course before starting the surface course. In these cases a tack coat is usually required between courses. Logistics of placement are matters for the engineer to think about before the first load of asphalt mix is placed, and good engineering judgment is usually the guiding rule.

Essentially, inspection of the surface course is the same as described for the leveling course except the method of placement is altered by the use of a paving machine in lieu of the blade. Texture is important on the surface course, and in recent years most organizations have been making more and more use of pneumatic-tired rollers to improve texture. This is particularly true of those roads which will not be subjected to heavy traffic counts. Steel-wheeled rollers are always used for the final rolling, regardless of the use of pneumatic-tired rollers. The allowable surface tolerance is ⅛ inch in 10 feet when tested along the centerline. Inspectors should be expected to check this item for conformity.

An extremely important item in any paving job is the joint, both longitudinal and transverse. The California Division of Highways does not specify the exact manner in which a joint is to be made except to state "... before placing the surface course adjacent to cold construction joints, such joints shall be trimmed to a vertical face in a neat line transverse or longitudinal to the surfacing. Transverse surface joints shall be tested with a 10-foot straightedge and cut back to conform to the requirements hereinafter specified for surface smoothness."

Because there is some hand work associated with transverse joints, street inspectors in California are encouraged to hold up the paving machine until the transverse joint has been made satisfactorily. This will insure more workmen for the hand work and an ample supply of hot material. Good workmanship in the longitudinal joints is also important to the inspector, and he should constantly check these joints for good surface characteristics.

One very important item not yet discussed in sufficient detail is compaction of the mix. Reference has been made to the significance of temperature to rolling. However, it is important to mention such items as equipment and methods.

Rolling equipment may be power rollers of the tandem type (8T), three-wheeled type (12T), or the pneumatic-tired rollers with a weight per tire between 1,000 and 2,000 pounds.

The main items of concern to the inspector relative to rolling are:

1. That equipment can reverse directions without shoving the mix.

2. That rollers can be cleaned continuously during rolling.

3. That a sufficient amount of rolling equipment to keep up with production is on the job. (California specifications require "one roller for production of less than 100 tons per hour and one additional roller for each additional 100 tons or fraction thereof per hour.")

4. That rolling should commence at the outside edges of the mix and progress toward the center or highest portion.

5. That initial rolling should be made as soon as possible after the mix has been placed. This is the rolling that achieves compaction and "sets" the mix.

6. That the power wheel is in front when rolling a "fresh mix."

7. That final rolling should not be started until the mix has cooled sufficiently to allow rollers to iron out all previous marks without creating excessive ridges.

8. That all longitudinal joints have been properly rolled to a smooth surface.

The street inspector is cautioned against over-rolling an asphaltic mix. Experience in California has indicated that over-rolling a mix of borderline stability may have a detrimental effect. Additional compaction will be achieved by vehicular traffic; this type of traffic seems to do a good job of "setting" these borderline mixes.

In the event that roller marks are extremely difficult to eliminate, the street inspector should check for too heavy a roller, too hot a mix, or excessive speeds of roller. If adjustments of these items do not correct the poor rolling condition, the resident engineer should be notified, since a check of the mix stability may be necessary, or possibly a heavier grade of asphalt is required.

In summary, a possible check list for street inspectors is given below:

1. Inspect equipment at beginning of job and as necessary during lay down.

2. Inspect subgrade for proper surface characteristics.

3. Inspect prime coat and paint binder prior to placing plant mix.

4. Collect weight certificates continuously. Use these certificates to check rate of spread.

5. Inspect windrow ahead of grader for proper size.

6. Check all joint construction, both longitudinal and transverse.

7. Check mix temperatures continuously. Maintain temperatures as low as possible.

8. Check rate of operating mechanical spreaders.

9. Check rolling procedures to obtain adequate density without excessive cracking.

10. Check smoothness of leveling course.

11. Contact plant inspector if any changes occur or need to be made in the mix.

It is hoped that this presentation may be of interest to street inspectors not familiar with California techniques. The writer hastens to add, however, that conditions vary from North to South, and what may be satisfactory in one area is not necessarily satisfactory in another. The procedures are essentially the same everywhere, but the variations are unlimited.

HOW TO GET THE MOST FOR YOUR DOLLARS SPENT ON TIMBER HIGHWAY STRUCTURES

CHARLES F. CRAIG

If we are to achieve the economy mentioned in the title, it is necessary to utilize stress grade lumber in your design and construction programs. Some of you are old enough to remember when nearly all the structures in this area were of timber. Its use in the highway field was retarded due to military demands during the war years, but once again it is gaining favor among highway engineers.

Probably the most fertile field of waste lies in specifications. Most of you are bound by a set of basic specifications issued by some governing bureau or agency. Most prevalent are state highway or federal specifications, both of which make reference to industrial specifications such as the rules of the West Coast Bureau of Lumber Grades and Inspection for grading of lumber, or the Manual of the American Wood Preservers' Association for pressure treating.

Industrial specifications are constantly undergoing changes and improvements, so when referring to such specifications always specify "latest edition" or "revision." The current rule book for Douglas fir stress grade lumber is Rule Book No. 14. It has been in effect since 1947, yet we still find specifications based on Rule No. 12, which has been out-of-date for almost eight years.

We constantly receive specifications calling for structural grade lumber, with no further identification. This term "structural" covers several stress grades ranging from 1,100 f to 2,150 f, yet we know the design engineer used some definite stress level in his calculations. When in doubt specify the exact stress level required, and industrial engineers will supply the proper grade.

Just to complicate the issue, I want to mention the fact that Rule Book No. 14 also is about to be dated. The Douglas fir industry has been working on a new set of rules and probably by the end of this year will publish Rule Book No. 15. When this is accomplished, we hope that engineering with, and specifying Douglas fir will be a lot easier. Regardless of the species of wood with which you are designing, you should have a copy of the latest edition of the National Design Specifications published by the National Lumber Manufacturer's Association. Other specifications dealing with wood which should be in your files, cover glued laminated materials. You can use either National Design Specifications or the publication issued by the West Coast Lumbermen's Association entitled "Structural Glued Laminated Lumber."

To get the most economical product, reference your materials to standard industrial specifications. References are made constantly to specifications that are outdated. Have enough faith in the industry and the engineers who work on specifications to specify the latest edition, then you will get the very best up-to-date product.

Looking back to your college days, some of you recall an engineering handbook entitled "Douglas Fir Use Book." This book is so out-of-date that it should have been retired years ago. It is surprising, however, to note that many people still use it. It is now being revised, and as soon as the new grading rules are printed the new Use Book will be published. All the best and latest tables you need to make engineering with wood easy, bound in a colorful green cover, will be available for your engineering library. Another publication of interest to you is a new plan book devoted to timber structures, now being prepared by the Bureau of Public Roads. We don't know when this will be released, but probably sometime this year. Mr. T. K. May from the West Coast Lumbermen's Association is the guiding light from the wood industry, and we hope that his committee comes up with some new ideas on timber design for this publication. When you need a new structure it will be simple to use standard, already properly engineered references approved by the Bureau of Public Roads.

After specifications, uneconomical timber design is the next greatest source of waste. In speaking of designs, probably we should start with the foundations. The first timber item which comes to mind is timber piling. This is where one of the greatest wastes occurs. We hesitate to urge too much economizing on foundations. However, it is an established fact that pile loadings that have been used in the past and that you find in most of your building codes, are ridiculously low. For instance, on a friction pile the only way you can actually arrive at an accurate design load is by application of test loads. The Washington Highway Department ran some tests this summer on the First Avenue South Bridge in Seattle. On a 65- to 70-foot pile with a 10-inch tip, they loaded in excess of 80 tons per pile, and thus realized a design loading of 40 tons, with a safety factor of 2. We have had the same experience in Portland, where pile tests for a new dock were made with an 8-inch tip; 60- to 80-foot piles. Test loads have been carried in excess of 60 tons, so they are able to use a safe design load of 25 to 30 tons.

The real saving can be achieved when you drive piling to refusal. If you are driving an end-bearing pile, or are driving to refusal, the pile should be analyzed as a short column. Few engineers make such an analysis. They take a value out of the code or handbook which is ridiculously low, and as a result often use several more piles than required.

Much of the highway work is done with 20- to 40-foot foundation piles driven to refusal, and the safe loading P/A (allowable load divided by the cross-section area) should not exceed the value C (allowable bearing stress), which can be assumed at 1200 psi. Therefore, a pile with 100 square inches cross section can carry 120,000 pounds if properly supported laterally. This is much in excess of the loadings usually noted in highway design. If 60 tons are an allowable load on a short pile for some conditions and you have been using only a 20-ton value, you have been wasting money that belongs to the taxpayers.

In general, money can be saved by standardizing designs. When a job comes through that is the same as the one turned out previously, the engineering costs are cut down. Suppliers can pull out that old order and repeat it with quite a saving in overhead costs.

Utilize the lower grades of lumber. For bridge work (short spans up to 20 feet), the most economical design is probably laminated 2 by 12's. From 20 to 30 or 40 feet, the old stringer type design using solid saw materials is probably the most economical. Beyond 30 to 40 feet, and up to 70 or 80 feet, glued laminated construction using glued laminated pressure-treated girders is probably the most economical. There is a breaking point beyond which timber trusses will show a saving.

The item that raises the price more than anything else is the high cost of labor. Most of the timber jobs are installed by carpenters or pilebucks, who are making more money than some of the design and supervising engineers. If you are to cut down on the high cost of labor in erection and field assembly, specify preassembling and precutting.

It then fits together like a jigsaw puzzle when delivered, and eliminates high jobsite labor costs.

Two of the things that raise the cost of lumber are nonstandard surfacing and nonstandard sizes. You know that lumber comes in nominal sizes and commercial lengths, and if you depart from these specifications you will be paying for something special. Don't specify S1SE or S1E unless absolutely necessary, because you are getting the same net section as the S4S or S2S—the material cut and surfaced to American Lumber Standard sizes. If the inspector culls the nonstandard material, the sawmill man must remanufacture the lumber, as there is little demand for the odd surfacings. It involves considerable additional work and raises the ultimate cost, so whenever possible we should utilize the material as it comes out of the mill. Generally, lengths up to 20 feet are the most economical. Beyond 20 feet, $2.00 or $3.00 per M is usually added for each 2 feet. Material up to 30 feet can be obtained without much trouble. When you start specifying solid-sawed stock longer than 30 feet, you have limited a large part of your production. In general, therefore, try to specify lengths under 30 feet. Specifying material involving special working, or available from a limited number of suppliers, increases the ultimate costs and is not economical engineering.

One of the limitations we find in specifications that causes nothing but headaches is that limiting the amount of sapwood. Sapwood and heartwood of Douglas fir are of equal strength and, if the material is to be treated, sapwood takes the preservative better than the heartwood. It is like the term "old growth Douglas fir." "Old growth" has reference to the virginity of the tree and has nothing to do with the grading or structural strength characteristics. Grading of the timber takes care of your design stresses, and you don't care where or when it was cut as long as it meets the requirements of your specified stress level.

One of the other items costly to engineers is inspection. The State of Oregon accepts grade-marked stock, or that covered by a certificate. The cost of a certificate generally runs $1.50 to $2.00 per M, which is a hidden cost, whereas grade-marked stock usually can be obtained with no extra charge. Here again, try to utilize in your specifications what is available for satisfactory inspection.

Materials delivered to a jobsite should receive the same protection accorded any high quality product. The life of pressure-treated timber and piling can be shortened by rough mishandling of the materials. Avoid dropping, dumping off trucks, or allowing material to slide down embankments. It may be an inexpensive way to handle the immediate problem, but rough handling is economically stupid when the ultimate cost of possible damage is considered.

Sometimes you fellows will hold up specifications and plans for months. All through the winter you think, "I'm going to get that out tomorrow," or "We have to get it into the contract stage." Finally you get it into the contract stage, but you have used up all the construction time, so you write in a stipulation that the contractor must start work tomorrow and finish the job almost immediately! This is slightly ridiculous because you know before the start that it is going to take 45 to 60 days to obtain the lumber. Practically all material for engineered structures is cut especially for the job, and sawmills normally take 30 to 45 days to produce an average bridge schedule. From the mill it goes into the pressure-treating plant, where it takes two to three weeks to properly frame, treat, inspect, and deliver to the jobsite. Normally, you should allow a contractor at least 60 days to get started. Once he gets the material, it goes into place fast and perhaps he can finish the job in ten days or two weeks.

If you have a design on your table and you know you are going to need it in six months—put it out for bids. We have an example of that now. The Bureau of Public Roads this year is building two bridges in Oregon at Annie Springs and Goodbye Creek near Crater Lake. These jobs were put out for bids last fall, and are not going to be built until this May or June.

Don't penalize the contractor by making him liable for materials on a fluctuating market. Let him know as soon as you can if he is to receive the award. Then he can give the materials' supplier an order to start cutting before the price changes.

I think we had a very appropriate remark this morning about permanent bridges. As you recall, Mr. Gray said they built only permanent type bridges and he referred, among other things, to treated timber. We still find people who are buying high priced lumber and installing it untreated, then wondering why it fails after a few years. When the cost was $20 to $30 per MBM for lumber, you could afford to let a few pieces decay or fail, but nowadays you are paying in the neighborhood of $80 to $100 per M. You now have a sizeable investment in your engineered wooden structures and cannot afford to risk the chance of failure from decay or termites. People who use untreated wood for highway structures don't deserve sympathy when their structures fail because, for a small additional charge, they could have had the material pressure treated, making it permanent. Pressure treating should be looked upon as insurance for the investment.

Other cost factors that should be taken into consideration are the penalties incurred by laborers. In some areas laborers extract from the contractor a "creosote penalty." This means that if they are handling creosoted material they get extra compensation. This can add up, so in making your specifications consider salts treatment. With salts treatment the contractor does not pay this extra penalty, and every saving should be considered. It is these little things that affect the installed unit costs and sometimes make them appear ridiculous.

Generally, freight costs are such that material should be delivered in truckload or carload quantities. If you are buying material for a bridge job, purchase the entire schedule and have it delivered in one load. Freight and handling of long lengths can be a major problem. The Forest Service builds a lot of bridges miles from nowhere. They build with glued laminated stringers 60 to 80 feet long, and it is quite a problem to transport them into inaccessible sites. Before you design something with long lengths, make sure the twists in the road are such that a man with a packhorse or steerable trailer can make the traverse. Occasionally you may be embarrassed by the fact that you have designed something and cannot get the materials to the jobsite.

One of the reasons the Forest Service uses so much treated wood is because of the high salvage value. The economic life of the bridges is based on a 50-year life, but Kelley Heffner, the regional engineer at Portland, expects 75 years without difficulty. During this life span they will probably realine the road—it is easy to remove these pressure-treated structures and move them into new locations with little loss of time.

There are many bridges here in the state that you may drive over every day without knowing they are of treated timber structure. The McCullough type composite decks on 99W going out of Portland were built in 1934. At that time, C. B. McCullough stated they would have a life of between 30 and 50 years. The cost of the treated timber in the structures, based on a 20-year period, has run less than $0.05 per lineal foot of bridge per year. It is hard to beat these figures.

One final word of warning—beware of the dippers. Certain people will tell you they can dip lumber in preservatives and gain the added life and protection. This is strictly propaganda and should be ignored. Dip treating wood is like washing your feet with your socks on. You get them wet, but you don't get the desired effect. There is no substitute for proper pressure treating.

People will argue about the relative merits of various preservatives. Federal Specification TT-W-571 probably is as good a reference as any. It lists practically all of the available commercial treatments. There is a time and place for everything, and certain types of preservatives are better for certain installations. If you are not qualified to make a decision yourself, call for expert advice from the Wood Preserver's Association.

Discussion:

COMMENT: You have indicated the use of various specifications and their availability; I want to assure you that, from the county level, they are difficult to obtain. For example, to obtain Rule Book No. 14, I have had to write and include the cost as many as three times before getting a copy.

COMMENT: If that gentleman will write Timber Structures in Portland, we will be glad to send him a copy.

MR. CRAIG: We have a representative of the West Coast Lumbermen's Association here, and should have him offer an explanation. Actually, the lumber industries are not very good promoters, but he will make sure you get a copy of Rule No. 14 before you leave the room. When the two new books come out: Rule No. 15 and the Douglas Fir Use Book, I hope they are circulated to every design man who knows anything about wood.

COMMENT: We here in Oregon and Washington, where timber is our primary industry, have the West Coast Lumbermen's Association, which I think is outstanding. Many of the specifications you have on the table there, even including the laminating specifications, are sent free when you write to the West Coast Lumbermen's Association for the material—there's no question about it!

QUESTION: Can you paint over pressure-treated wooden guard-rail posts?

ANSWER: If you are using an oil-treated post it must be air seasoned for quite some time before you can paint it. Oil under pressure is forced into the cells of the wood when using an oil treatment. Generally, if you are planning to paint, I would recommend use of a salts treatment. Actually, the trend is away from painting. The costs are considerably less by leaving the posts unpainted; they will last just as long; and you have not achieved anything by painting. The Idaho Highway Department uses a white rail on black posts, and it is as attractive an installation as you will ever see. Maintenance work of painting each year is eliminated by using dark treated posts. Here in Oregon the Highway Department has used some galvanized rails on dark pressure-treated wooden posts. This should provide an economical, trouble free, and low maintenance installation.

QUESTION: What about incising?

ANSWER: If you specify timber per AWPA Specifications, you should get incising. Everything thicker than two inches that goes through our plant is incised automatically. It is a necessity to arrive at uniform penetration. On past occasions some work has been done in Oregon without incising. Two plants in Oregon could not incise, and the Highway Department was a little reluctant to force out-of-state business. However, the State of Oregon now insists on incising.

COMMENT: We have an argument there in our area.

MR. CRAIG: I don't think you should ever have an argument. The fact is that incising is necessary if you are going to get the job done right. As long as you are paying for a quality product, you might as well get it done per the specifications.

QUESTION: What are the best pile specifications?

ANSWER: The best pile specifications you can get today which satisfy both design and use are ASTM Specifications. Either this specification or Federal Specification MM-P-371 is good.

Once in a while someone specifies a rigid additional ring count, but this ring count is of no value if you are using foundation piling and it is of dubious value for trestle piles. The most rapid growing stick I have seen is usually rigid enough for trestle piling, particularly with the lateral braces utilized. The State of Oregon does not require a ring count. I think they have adopted ASTM Specifications. They have a most economical buying specification, and piling deliveries are usually prompt. A few thousand sticks are maintained in our yards for emergencies. When the engineer is in a hurry he will come in and say, "Give me something quick, I have to build a bridge," and you see that he is supplied. Perhaps two weeks later he writes specifications of a nature that you are unable to fulfill for months. Actually, the emergency procurement utilizing normal yard stocks is probably just as good. I would recommend that you adopt the ASTM Standards for your pile specifications.

QUESTION: How is Penta treating accomplished?

ANSWER: Penta is injected into the wood in the same manner as creosote or any other oil treatment.

QUESTION: Can Penta-treated material be painted?

ANSWER: Penta is mixed with an oil carrier. It is generally a drier, cleaner treatment than a creosote-petroleum mixture, but unpaintable until having weathered for a considerable time. It does not impart a dry, clean surface like the salt treatment. The type of carrier oil in general use is dark in color, transmitting a light chocolate brown coloring to the product.

QUESTION: They are using Penta for utility poles throughout residential areas in practically all of the western cities. Why paint them? Why spend money?

ANSWER: Once you use paint you have to continue, and it becomes rather expensive. Pressure-treated products treated with toxic oils do not need painting.

QUESTION: What is Chemonite?

ANSWER: It is a wood preservative containing copper and arsenic salts. Locally available salt treatments are Chemonite, Wolman, and Boliden. Federal specifications show relative retentions of each for various installations.

QUESTION: How do you satisfactorily pressure-treat field cuts and holes?

ANSWER: If it is essential to bore holes on the job, fill them full of hot preservative which will soak into the wood. Several hot applications with the same preservative originally used will suffice.

QUESTION: What about holes bored in piling?

ANSWER: Use a bolt hole treater which applies pressure to the preservative and is the most satisfactory method of field treating holes.

QUESTION: When will the new Bureau of Public Roads' design book be published?

ANSWER: I believe the book should be ready this fall. The draft is being written now in a committee and, if it doesn't get sidetracked, should be approved and printed this year.

One additional thought—if you have more questions like this, we have several people in the industry willing and available to help. If you have a problem don't hesitate to call upon me or Mr. Bill Bond of the American Wood Preserver's Association, to help with your difficulties. Questions concerning technical uses of wood should be addressed to the West Coast Lumbermen's Association.

Panel Discussion on

Practical Application of Standards for Signing and Striping

F. B. CRANDALL:

It is going to be a rather difficult change of pace to step down to such a mundane subject as signing after hearing Mr. Baldock speak in billions of dollars. However, signing is an important adjunct to our road facilities and one which, as I have said on other occasions in discussing illumination, is a selling job. Moneywise, the relatively smaller items, such as signing operations, illumination, et cetera, are going to play an important part in getting a desirable reaction and doing a selling job with the motoring public. They are the ones that put up the money, and it is their project. When the public drives over one of the new facilities into which their money has gone, they see at a glance what, in a large part, controls their reactions. From that standpoint, I think proper attention should be given our signing to see that we properly serve our public and get the desired reaction from them.

Mr. Widdows, Mr. Head, and myself will break down our discussion more or less, wherein I will talk very briefly about national trends, general practice, and the uniform manual. Mr. Widdows, who is directly concerned with the installation and maintenance of our signs and control devices, will touch on more specific matters concerning actual practices, maintenance, erection, et cetera, with respect to the signs. Mr. Head will be anchorman to the extent of checking us on items we have neglected to discuss that might be of interest to you.

In discussing the sign situation, we usually touch a bit on the Uniform Manual, with which I believe most of you are acquainted and which most of the states, counties, and cities over the country look to as a guide in their signing operations. In connection with the manual, it may be of interest to know that recently there have been some revisions made which have been put up in a small supplemental pamphlet. To those of you who have a copy of the original manual and make use of it, I would suggest you arrange to get a copy of the recent supplement.

It may be of interest to know the highlights of the revisions made. I think you are all acquainted with the changeover to red stop signs. Many of the cities and counties are already moving forward with the changeover, which is also the plan of the Highway Department. Mr. Widdows will be able to give you a better indication than I on just what the time schedule will be. I know he has had many requests from cities wanting to know when the Highway Department is going to get started on the changeover to red stop signs.

Also incorporated in the revision to the manual is the "yield right-of-way" sign. I might say that we do not follow the manual in all matters; we have a little difference of opinion in our state as in some of the other states, but the "yield right-of-way" sign is a relatively new idea that is being experimented on in some parts of the country. It was included in the manual not necessarily from the standpoint of advocating and setting up any warrants for its use, but rather because it was used in some places over the country. If it is going to be used, probably there should be some standard type of sign with respect to shape, color, and message. Here in Oregon we have not advocated it, nor has it been approved by the Highway Commission. Without a revision of the present law, the "yield right-of-way" cannot be used because it would be in conflict with the standing law that states that the man on the right has the right-of-way.

There are minor changes in the wording of some signs. For example, the passing nomenclature will be modified to read "Do Not Pass" and "Pass With Care," according to the manual. We do not follow that specific wordage here in Oregon. I believe you are familiar with the sign we use indicating unsafe to pass, and the barrier stripe in relation to the centerline sign. Some of the states have written into the law that it is illegal to make a passing maneuver where you have the barrier stripe. In Oregon it is not written into the law, but is purely a service to the motorist—a warning device that it is unsafe to pass.

Something we have not used to a great extent in Oregon is the so-called Cardinal direction marker, which is a sort of supplement to the route marking sign. A person moving along a particular route may become confused as to which direction he is proceeding on a highway. Therefore, some modifications in the words on the sign message have been made to show this.

From experiments made, the minimum mounting height for the bottom of signs in rural areas has been raised to five feet. This was done primarily to get the signs out of the trajectory of splash.

Warning signs are to be placed farther in advance of dangers ahead. This is logical because our speeds have increased in the last few years to the point where we are going to have to move out a little farther to provide for adequate safe stopping time.

On traffic signal installations it is required that at least two signal faces be visible on the approach to an intersection. Many of you know the manual does set up certain warrants for the justification of signal installations such as signalized controls at an intersection, based on volume. They have increased the minimum warrants for signals. The old copy on the warrants prescribed that you should have a certain average vehicular volume per period of eight hours. The new one requires that it will be a certain volume for each of the eight hours over an eight-hour period. This, in effect, raises the warrants for signalization. This is a little off the subject of signs, but may be of interest.

These roughly comprise the changes made and contained in the supplemental pamphlet on revisions. I recommend that anyone who uses the manual (and it is a good one to use), acquires a copy of the supplement for his reference library. It may be obtained from the U.S. Printing Office in Washington, D.C., for $1.00 a copy.

Frequent requests come into the office for an Oregon manual, but we do not have a state manual, as such. By reason of our centralized organization we have never had occasion to need one for our own work. Mr. Widdows directly controls the signing operations from the Salem office. In a state organization that is decentralized and the signing is left up to district organization offices, a manual probably is needed for uniformity. Because of the many requests received, we are now, and have been for some time, compiling a manual for Oregon. It should be off the press sometime within the next six months.

In a way, this matter of uniformity and standardization of signs has been pretty much an obsession in Oregon. We do have, if I may say so, a very good national reputation for adhering to a standard sign setup. People driving through the state get uniform signing, whether it is out in the rural areas or within an incorporated city. Good signing should be predicated on a minimum of copy to convey the message. Wording should be kept down and lettering large enough that people can easily read it. Simplicity in the message, even to the extent of being grammatically incorrect on occasions, may be warranted. Much can be accomplished by symbolization, as in the curve or cross road signs.

A recent attempt at international standardization has brought some of the foreign countries into the picture, and they have tried to get together internationally on a common standard. They went a little overboard in an attempt to go to symbolization, which did not work out.

A companion theme to simplicity of sign messages has been advanced. When a situation arises requiring a lengthy message to get it across to the oncoming motorist, it might be broken up into units of several signs to form a series—the Burma Shave way. I think you will find that this practice is followed in our signing operations.

I know there are many county and city people in the audience, and I would like to stress the matter of uniformity in your operations. We occasionally still see nonstandard signs. For example, the use of octagonal stop signs to make school signs, and I believe it was Al Head who indicated he saw some stop signs not long ago that were black on white which, of course, is not standard. Signs of this type certainly do not create good feeling with the motoring public. It is irritating to run into different types of signs for similar conditions. So, I will again caution county and city people to adhere to standard signs.

W. O. WIDDOWS:

We manufacture in our own shops about 50% of all the signs we use. If the signs are 24 inches in diameter or less, we try to buy them in metal, but if they are larger than 24 inches they are generally made of marine plywood in our own shop.

The red stop sign has probably created the most interest in the current standard changes, and we are manufacturing them at the present time. They are made of a new type of metal known as 61ST6, a strong aluminum alloy. It cannot be bent around the post, the reflective sheeting used on it stands out very well, and it does not require advance treatment.

The minimum height has been raised on all signs—from 42 inches to 5 feet to the centers. We accepted a standard of our own many years ago of a 7½-foot height on a stop sign so it could be viewed over a parked car. We are using that in the rural areas as well as in the urban areas.

Most of our signs are mounted on Port Orford cedar posts because we found this more economical in the long run. Treated fir or any other treated wood probably would give as good results. We treat the Port Orford cedar with pentachlorophenol as we have found that the paint is better retained and the decay is reduced with this treatment. We do not use metal sign posts in the rural areas because we have a condition there where the soil is very soft. Unless a special shoe or other bracing is put on the posts, wind racking is so bad that keeping the signs in a plumb position becomes a problem. To some extent this is a problem in the city, although we do have some 2-inch pipe installations in urban areas.

Most of the signs manufactured in our shop are of marine plywood. They are edge treated and given three coats of paint. We can expect a life from them of about five years. We estimate metal signs will last eight to ten years, but very few stand for their potential life because they are usually subjected to vandalism.

We have a new unit in which I am quite interested. It is a sight post made of corrugated metal. We buy the raw metal cut to size (8 inches wide and 5 feet long), and put on a prime coat and two coats of white enamel. By putting a wooden block on the head it can be driven into the ground until only 2 feet 8 inches remain, which we consider the proper height. We have a 6-inch band 3 inches from the top of reflectorized sheeting. This post has considerable target value and we have found that we can install it for a third of the price of an equivalent wooden or concrete sight post. We also contract this type of installation, but to date we have not contracted the finishing of it. Where placed under contract, the contractors have set the posts and we have done the painting and reflectorizing. I might state that the cost for large quantities installed by us is $3.50 a unit.

If a curve is not too severe, I believe the motorist benefits more from a sight post than from a curve sign. If there is a question as to whether or not it should be a curve sign or a sight post, I would say that probably the sight post would win favor because the cost is comparable if the central angle of the curve is not too large. You can put in about three sight posts for the cost of one curve sign. Because sight posts are placed directly in line with the motorist's vision, he is bound to pick them up. He might miss a roadside sign that is set 8 or 9 feet back from the edge of the pavement.

Our striping program, in which we are going to the white broken centerline, probably will get underway this month. In February we can generally expect ten days or two weeks of good weather and we will start renewing these sections with the new white broken line. As you all know, we will use the white solid line as a barrier line, which is the marking we have at the present time.

J. AL HEAD:

I think more of us should be cognizant of the legal implications involved in our signing and painting programs. In connection with this, an interesting experience took place this morning concerning the field of standardization of signs and pavement markings.

One of the attorneys for the department had a request from an attorney in Portland who wanted to know what the standard was for painting pedestrian crosswalks. The Oregon Revised Statutes contains a section that states, "... the standards shall be as prescribed by the State Highway Commission and duly adopted ..." The attorney asked what our standard was, and I referred him to the National Manual on Uniform Traffic Control Devices as being the standard we use for the solid barrier line delineating the crosswalk.

As you may notice in driving around our cities and state, there are too many who do not follow the standard. Is there a legal implication? Is the responsibility on the side of the engineer who does not follow this standard? I don't know. Perhaps that is something we should think about.

Also, along that line, we are continually getting requests from attorneys with respect to speed zones. When were they established? What are their exact limits?

Mr. Widdows has been insistent that his crews place signs in exact conformity with legal action taken by the Highway Commission and State Speed Control Board. You men at the city and county levels have a legal responsibility to see that your zones are signed exactly. I do not believe that any of us has been taken into court for something we may or may not have done in the way of signing. However, there was recently a case in Eastern Oregon concerning Highway Department employees which had very great implications as it hinged upon the obligation and responsibility for signing.

Another point that came up is that people should learn the speed law in our state because it is an indicated speed. We do not have a "limit," yet some of the sign manufacturers still sell a sign reading "Speed Limit 30 Miles." The word "limit" is out of place in our state because it denotes a wrong action to the motoring public.

Mr. Crandall mentioned the manual we are currently preparing. I think it ties in with the comments I have just made. We are not familiar with what we should and should not be doing. I know those of us at even the state level cannot always keep up with the laws. When we have a manual, and we will have it before too long, it will be available to cities and counties. I believe when we get this we all will be able to sign and carry on our program in conformity, because none of us willingly violates the intent of the laws we try to administer or the signing program the legislators or administrators ask us to do.

Mr. Widdows mentioned the painting program. I believe that not too long ago Mr. Baldock forwarded to most of you at city and county levels, our standard for painting and markings as adopted by the State Highway Commission. Here again, it may occur to you to ask, "Why does the State Highway Commission adopt these standards, and why do they tell us what to do?" It is written into our statutes that centerline markings, striping, and other standards should be adopted and established by the Highway Commission. This gives one central clearing body in the state so that uniformity can be developed for the motorist as he drives over our streets and highways.

Discussion:

QUESTION: In connection with the standards and revisions, some of us are extremely busy in civil defense work. Has the National Committee done anything regarding signs for civilian defense use?

ANSWER (MR. CRANDALL): No, they have not gone into anything on civil defense signing. I imagine anything in that direction may come in a manner similar to what was done during the last war. Prior to our getting into the war, the Committee published a war edition to care for signing situations. I have not heard of any movement in that direction in connection with civil defense signing, but that is probably the way it would be handled.

QUESTION: I would like to get something cleared up with Mr. Widdows. It is rather eerie on the expressway as you drive out from Portland. On those reflectorized signs you can see that the shape of the post is perfectly reflectorized in front and the rest is rather dull. Why is this, and can it be remedied?

ANSWER (MR. WIDDOWS): That is a phenomenon they have not been able to beat as yet. We say that the post keeps the back of the sign warm, and one of the greatest hindrances to reflectorization, whether it is on buttons or beads, is a frost condition or a slight dew in the air. Humidity affects the reflective powers of the beads, and because the post keeps the back of the sign warm, the protected part is, therefore, the brightest spot on the sign.

QUESTION: What is the breakdown on the $3.50 figure on your posts?

ANSWER (MR. WIDDOWS): The raw post costs us approximately $1.10, although we have had cheaper bids than that. The reflectorization on both faces costs us $.70. That is $1.80 we have in the post so far. Two coats of paint, plus the prime coat (we use green zinc chromate prime plus two coats of white enamel) is sprayed on in the shop. The posts are stacked and all edges are sprayed at once. We spray 30 or 40 posts at one time in the shop. They are then put on an easel and flipped over by one man, another paints them with a spray gun. The painting costs about $.80, which gives us $2.60 and, allowing $.90 for placement, gives a total of $3.50.

QUESTION: Your price is for an 8 by 8 post, what would it amount to for a 2 by 8?

ANSWER: We have never contracted an installation for 2 by 8 posts.

QUESTION: In regard to destination signs, what is the reason for ours reading from the bottom up, as you might say?

ANSWER (MR. WIDDOWS): As you approach the intersection to a principal junction (we will take Portland as an example), we believe there are probably 95% of the people more interested in Portland than they are in the little town of Talent, for instance. Yet Talent is probably the next town you are approaching. There are probably ten thousand people interested in Portland and one in Talent. That is why we put Talent at the end, where we can drop it off.

QUESTION: There is something I would like to ask regarding uniformity. In driving through a town near here, if you watch the "wait-walk" pedestrian signals so that you do not have to come to a screaming halt, you can get through the intersection on an amber "wait." I have seen both clear "waits" and "walks," or green "walks" and amber "waits." Isn't there a standard for these signals?

ANSWER (MR. CRANDALL): We do have a standard for these. The "wait" is basically an amber lens with a black stripe with the white lettering of "wait" showing through. I think possibly the ones you have seen that do not follow this standard are installations in cities wherein the signal, if it is on an urban highway extension, was put in initially as a cooperative project between the state and city wherein the city and state shared equally in the capital outlay, installation costs, et cetera, and then the city was committed to maintain the signals after they were put in. Possibly what happens when a lens is broken is that it is replaced by a cheap one that is not standard. I know we have one in Springfield. I believe this is the situation where you have found nonstandard signals. I hope it is a rare instance because we try to keep our finger on them as much as possible.

QUESTION: Have you tried to clean the reflectorized signs, and if so what do you use?

ANSWER: (MR. WIDDOWS): We use a solution of Purex or any ordinary detergent of that type. A good, liberal solution of water and Purex will clean them fairly rapidly.

QUESTION: I would like to ask how you determine the spacings of the delineator posts.

ANSWER (MR. WIDDOWS): We space the metal sight posts on tangents approximatly 400 feet apart. We use a survey speedometer in some instances, and when we have construction survey stakes still in on a construction project, we use them. We use 400-foot spacings and stagger them. That is, there will be one on the right side, and 200 feet down on the left-hand side there will be another. The most important sight post on a curve is the one in the center of the lane—not the centerline, but the center of the lane. From that post, by proceeding around the curve, coming back on the other lane (inside lane), producing the center of the lane ahead and setting the other sight post, you can get an idea of what your spacing should be on the curve. The spacing might drop down to 30 feet on a really sharp curve. Headlights will not pick up the sight post on the inside of the curve, and we drop off quite a few of the inside ones. We unintentionally put in some that leaned, and the boys were accused of having gone out in the evening and putting them in, or having done something during the daytime that they should not have been doing. We found that they must be put in plumb, and we level every one. If you get them just a little bit off they look terrible.

QUESTION: How many posts will be picked up by the headlights at night?

ANSWER: On tangent you will probably see only two or three, depending on the clearness of the night. You cannot pick them up over

1200 feet. On a curve you will see all the way from six to ten, depending on the sharpness of the curve.

QUESTION: I understood you to say that the barrier stripe is going to be a white, solid line. Will this be in addition to the broken line?

ANSWER: Yes.

QUESTION: Have you developed a machine that will retrace the broken line satisfactorily?

ANSWER: We think so. We have two of them now. We found that when the weight of the paint machine operator is changed, the diameter of the back wheel is changed. For that reason when we use two operators, who change off every two hours in the heat of the day, we utilize a fifth wheel as a control wheel, which is unaffected by the weight of the operator. The fifth wheel rides free. If we find the skip is not hitting, we have a thumb screw adjustment the operator may turn to put pressure on the fifth wheel, which causes the wheel to decrease or increase in diameter. We also found that wheels used on small paint machines varied as much as an inch and a half in diameter on brand new tires. They are made like wheelbarrow wheels and the diameter is variable. Since we have had the fifth wheel we can get away from all these factors. I believe California also uses a fifth wheel type.

QUESTION: Do you use a 15-foot solid and a 25-foot skip?

ANSWER: Yes.

AGRICULTURAL SOIL MAPS AND THEIR ENGINEERING APPLICATIONS

JAMES H. MCLERRAN

Introduction

Before any engineering project which must depend on soil for support can be started, an adequate soil survey is now considered essential. However, budgets do not go as far as we consider desirable to perform this survey and, therefore, any shortcut method for obtaining reliable soils information would be desirable.

After recognizing the need for shortcut methods, it is time to look for methods that will serve this purpose. The requirements such a method must meet are: (1) it must provide information sufficiently reliable for the purpose that it will serve, and (2) it must provide this information at an economical saving over present methods. Three major tools used with considerable success are geological maps, air photos, and agricultural soil maps. None of these devices will provide answers to all our problems, but each provides a valuable supplemental tool in soils exploration.

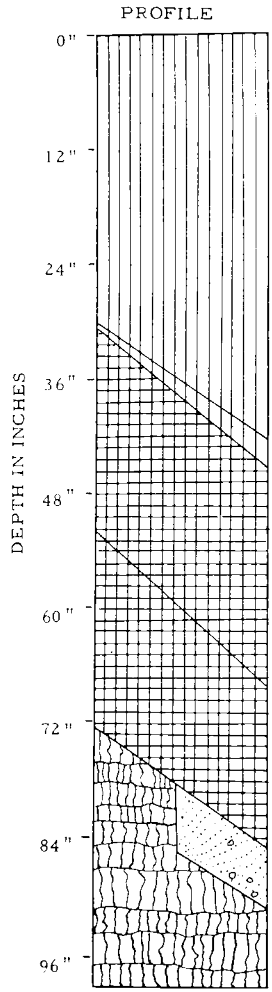
The Agricultural Soil Survey Map was prepared essentially to serve agricultural purposes, but the methods employed in preparing the map require a knowledge of soil origin and formation, and it is necessary to know some of the physical properties of the soil. The map is actually a soil map and not just a productivity classification map. It is usually adequate for the engineer, but the report describing the map units is not. The unfamiliar terminology of these reports is largely responsible for the lack of engineering usage of the maps. Also, earlier maps were not of the quality of the maps presently being published.

Use of information already compiled and available, such as the Agricultural Soil Survey Maps, can supply the engineer with a great deal of information when he has neither time nor money to expend in detailed investigations. While this data can only be considered as general, if properly used these maps and other agricultural soils information provide an engineer with an opportunity to correlate his experiences with soil types and to conduct more efficient and more economical soil surveys. The maps give area significance to information obtained from a single point, and the pedological soil name provides the engineer with an index to correlate and catalog his experience with the soils of his area. He can use the soil map to identify the soils, and the soil unit name to catalog his findings.

With the previously mentioned factors in mind, it was felt that the development of the use of agricultural soil survey maps would be a direct benefit to the engineers of the State of Washington. While these maps represent valuable information, the engineer busy with his other duties does not have time to interpret the reports. A project to develop the usefulness of the maps was started at the State College of Washington in November 1952. It was necessary to consider what would be required to make these maps useful. In some states they have made new maps and called them engineering soil maps. This was often done to reduce the detail of the agricultural maps. While this may be desirable in some areas, it was felt that to do this would be unnecessary with the maps available in our state.

It was decided that there were two major tasks to accomplish. One was to give the engineer a brief background in pedology and the pedological classification system and to point out the ways in which the maps could be used. The second and largest task was to interpret and translate the agricultural soil reports into the language of the engineer, and to provide applicable data on the engineering properties of the soil units mapped on the soil survey maps.

To accomplish this second phase, the *soil survey descriptions* were first translated into engineering terminology and engineering soil descriptions were prepared. Figure 1 is a typical engineering description. Data from the materials laboratory of the Department of Highways was then analyzed, and when the sampling site for a sample could be located on the map the data was assigned to a soil type. This data was then used to check the soil description and to prepare typical



LATAH SERIES

General. These soils have developed on alluvial deposits derived mainly from materials eroded from adjacent loessal soil and from areas of basaltic bedrock. The parent materials have accumulated under conditions of retarded drainage. They are associated with the Caldwell soils from which they are distinguished by the fine textured prismatic to columnar subsoil of the Latah profile.

Location. Local stream valleys in the region of loessal soil in Washington, Oregon and Idaho.

Description. The surface soil is a loose, dark, organic silt or silt clay. This organic silt extends to a depth of 30 to 40 inches. A light gray silt often found below the above layer varies from a mere coating to several inches thick. Below this is a heavy, waxy, compact clay silt of prismatic to columnar structure ranging from 20 to 30 inches thick. This is followed by a less plastic clay silt to a depth of about 72 inches. A thin sand layer usually follows with basalt bedrock below this.

Topography. Gently sloping to nearly flat bottom and terrace of local stream valleys.

Drainage. Low areas are subject to occasional overflow. Surface drainage is slow and subdrainage is retarded by the compact heavy subsoil. Water table is frequently high.

Engineering Problems. These soils provide poor foundation materials for structures. The soils of the top horizons are very poor for subgrade. The subsoils are fair to poor as subgrade materials.

Figure 1. Soil Description Prepared for Engineering Use.

laboratory test data tables to supplement the description. Table 1 is an example of test data tables prepared. To check the descriptions and to provide engineering data for all the soils, field sampling was also necessary. A total of 625 samples was taken and tested in the soils laboratory of the Division of Industrial Research to complete the work on the first five counties. Engineering reports prepared in this manner, with climate and geology summaries, have been published for Snohomish and King counties. A report for Skagit County is at the printers, and reports for Whatcom and Island counties are being completed.

The engineer using the maps can accomplish more if he has some understanding of the principles of pedology and the principles used in identifying and mapping the soils. Pedology is the science that deals with the soil as a natural body. It includes the study of origin and formation of the soil, determination of physical and chemical properties, and classification. Soil to the pedologist is only that portion of the earth's mantle in which soil-forming factors are at work developing a soils profile. Other unconsolidated materials are considered to be soil-forming materials.

TYPICAL LABORATORY TEST DATA

Soil: Everett gravelly sandy loam

	HORIZON OR DEPTH						Source of Data
	2'-8'	0'-10'	0'-8'	2'-12'	12'-13'		
% Passing 1½"	91	89	93	98	100		Highway Materials Laboratory Sample Numbers: 7792 7935 7936 7308 7309
% Passing 3/4"	78	77	82	96	99		
% Passing #4	56	56	66	92	96		
% Passing #10	51	52	61	89	93		
% Passing #40	35	41	51	78	77		
% Passing #200	8	15	23	6	5		
% Sand							
% Silt							
% Clay							
Liquid Limit		18	21	-	-		
Plasticity Index	N.P.	N.P.	3	N.P.	N.P.		
Opt. Density p.c.f.		121.2	111.0		103.8		
Optimum Moisture		12.0	15.4		12.7		
Swell Pressure							
R Value	78	80	70	75	76		
HRB Classification & Group Index	A-1-b(0)	A-1-b(0)	A-2-4(0)	A-3(0)	A-3(0)		
A C Classification							

Table 1. Typical Laboratory Test Data Sheet.

Briefly, soil is the result of soil-forming factors acting on soil-forming materials. Soil-forming materials are fragments of rocks and minerals produced mainly by physical weathering and changed somewhat by chemical weathering. Soil is developed from this parent material by the action of climate and organisms (particularly vegetation) conditioned by topography and length of time in their effectiveness.

The pedological system of classification is based on the principle of the recurring soil profile and that soils can be identified in place by this profile. The principle of recurring profile means that if all five factors of soil formation, as mentioned above, are the same in different locations, then similar soil profiles will occur in these different locations.

The soil profile

The *soil profile* is created by biological activities, especially plant organic material and the movement of clay colloids and soluble materials by drainage—all influenced by climate, time, and topography. This modifies the parent material into zones called *horizons*. A combination of horizons in a vertical cross section constitutes a soil profile. The soil profile, which is developed by these soil forming factors, has significance to the engineer except in areas where the profile is not developed to more than a few inches. The soil profile is customarily divided into three major portions, as shown in Figure 2. The soil in these horizons varies from one horizon to the next in either physical or chemical properties, or both. Within one horizon there is a uniformity of texture, structure, consistency, color, and other characteristics.

The A horizon is the surface mineral horizon with the maximum organic accumulation and a depletion of clay minerals. The B horizon is a major horizon characterized by, (1) an accumulation of clay and oxides of iron or aluminum, (2) a blocky, columnar, or prismatic structure, (3) development of stronger red or yellow colors, or (4) a combination of these characteristics. The C horizon is the relatively unaltered, unconsolidated parent material.

The *subhorizons* of these major horizons are also significant to the engineer. Within the A horizon there are three subhorizons. The A_1 horizon is that layer within the A group that has a maximum of organic accumulation, sometimes called the topsoil. The A_2 horizon is a light-colored layer, often ashy grey, that has had a maximum depletion of clay minerals, oxides, and organic material. It is significant to the engineer in that it is usually followed by an impervious plastic or a cemented nonplastic horizon. It also is a structureless, unstable silt and indicates the movement of a great deal of water through the soil and, therefore, can indicate problems such as poor drainage and frost potential. The A_3 and B_1 horizons are transition horizons from an A_1 to the B horizons.

The B_2 horizon is the horizon of maximum accumulation of clay or

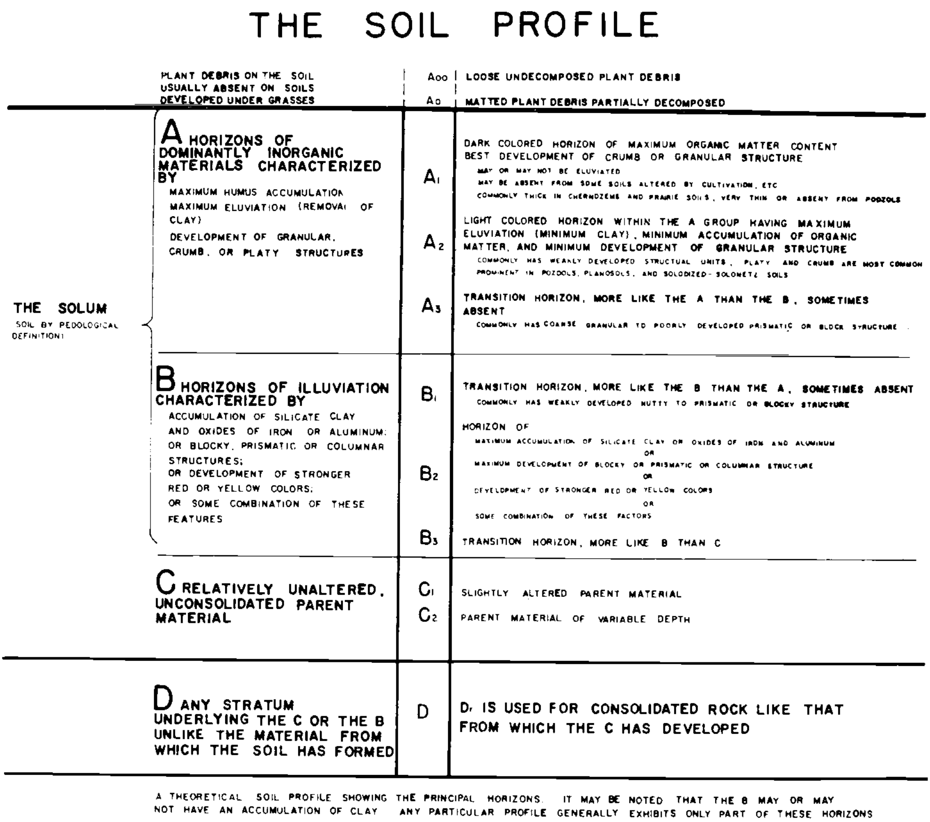


Figure 2. Soil Profile Chart.

oxides of iron and aluminum within the profile. This is sometimes only slight and the other characteristics listed in Figure 2 may predominate. However, if it is preceded directly by an A_2 horizon, it is then usually an impervious plastic or a cemented nonplastic material. The B_3 horizon is another transition zone. It must be remembered that if the soil forming material is sandy or granular, then the B horizon has little chance of being plastic and the other characteristics listed will prevail. Figure 3 illustrates a soil profile with some of these subhorizons.

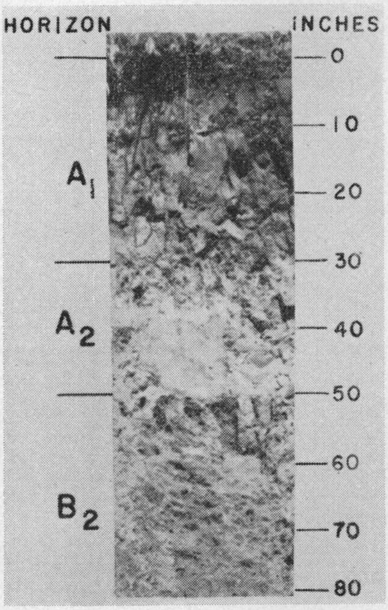


Figure 3. Profile of a Thatuna Soil.

The profile of a Thatuna soil is shown which illustrates some of the subhorizons. The contrast in color and structure of the A_1, A_2, and B_2 horizons shows up very well. These subhorizons have an engineering significance. The A_1 horizon is very organic and is, therefore, a poor engineering material. The A_2 horizon is a source of considerable trouble for the engineer. It consists of a very unstable silt and its very existence indicates trouble with water. This horizon in the soil carries a great deal of water laterally. This water creates slides between the A_2 and B_2 layers, carrying everything that lies above this zone. It brings water into the roadbeds if adequate drainage is not provided. The B_2 horizon is nearly impervious to water, and this forces the water to move laterally through the A_2 horizon.

The A-B-C profile designation does not apply to all soils. Soils such as muck or peaty soils and those formed from stratified water-laid materials have layers that do not fit the A-B-C nomenclature.

Pedological classification of soils

The classification units that concern the engineer are soil series and the soil types. The most important of these is the soil *series*, which is a group of soils developed from the same parent material, having similar soil horizons, and having essentially the same characteristics throughout the profile except for the texture of the A, or surface horizon. The soil series is named after the location of the area where it was first found. For example, the Astoria Series.

The soil *type* is a subdivision of the soil series based on the texture of the surface soil. The soil type name consists of the soil series name and the *textural class* name of the surface horizon. A soil type is a particular soil that has the same profile and the same characteristics throughout. A soil type within the Astoria Series might be Astoria silt loam.

How to use the maps

The soil survey maps can be useful to the engineer in many ways. Major uses for the maps can be listed as follows:

1. Soil reconnaissance surveys for the location engineer.
2. To locate sand and gravel for construction purposes.
3. To organize and check field surveys.
4. To correlate pavement performance with soil types.
5. Location of drainage problem areas.
6. Preliminary soils information for the foundation engineer.

Contractors can also find these maps useful in evaluating the construction problems they will encounter in an area, and this can aid them in preparing their estimates.

As soil reconnaissance survey tools, the maps may be used for preliminary selection of road alignment to avoid undesirable soil and drainage conditions and to take advantage of the soils providing the best subgrade support.

To locate sand and gravel deposits, the engineer needs only to be familiar with the soil units in the area which are developed from granular materials. Field surveys and sampling can be reduced to a minimum because it is already known where to expect sand and gravel. In the county reports being prepared for the aforementioned project, the soil types developed from sand and gravel deposits are listed.

The field soil survey along a proposed road location can be conducted much more efficiently with the soil map. The engineering characteristic of the material within any one soil area can be expected to remain the same. Therefore, the sampling can be spotted to check one or two sample sites for each soil type. Particular attention should be paid to transition areas along the boundaries of each soil type, and to areas where poor soils are near the location. The use of the map is an aid in preventing under-sampling as well as over-sampling of an area. It does not eliminate field sampling, but aids in organizing and checking field surveys.

The soil type names provide an orderly index for tabulating the experience of the engineer and the multitude of random tests run on these soils. Through the correlation of pavement performance with soil types, as shown on the Soil Survey Maps, a system for predicting performance of future pavements is established. The Michigan Highway Department has relied on this method for many years. When a pavement is found to fail in some areas and to be in good condition in others, the performance can often be checked against the soil type on the soil map. The change in performance will often coincide with a soil boundary. Or, it may be observed that in some soil types the pavement performance is poor in shallow cuts but good when the pavement is placed on or near the original surface. This condition may occur where there is a highly plastic B horizon. The reverse situation also often exists, especially for soils with highly organic top soils.

An engineer concerned with a drainage project can expect the soil map and the accompanying report to supply a great deal of information. Wherever any one soil is mapped, the internal and surface drainage characteristics will be similar. The Soil Survey Report gives the surface and the internal drainage characteristics for each soil mapped.

The foundation engineer will find that certain soil types have definitely poor supporting qualities and, if possible, should be avoided for a building site. An example of a poor foundation soil is the Latah soil, described in Figure 1. This soil is found in many available sites for grain storage buildings in Whitman County, Washington, and wherever it is mapped the engineer can expect the same profile and conditions. It often has a high water table among its other poor characteristics. The top 30 inches of this soil contains much organic silt and has an allowable bearing capacity of approximately 0.6 tons per square foot. The subsoil has a larger allowable bearing capacity, but may still not be capable of carrying the desired load. The engineer designing a structure to be placed on an area mapped Latah should be sufficiently warned to know that he is liable to have foundation problems. Fortunately, a bedrock floor is usually found within a few feet of the surface of this soil.

In conclusion, it should be emphasized that the Soil Survey Map can give the engineer valuable data, but this information is of general nature. Where precise data are required, it is necessary to resort to systematic sampling and testing.

Note: Bibliography may be obtained from Parts I, II, III, IV of the State of Washington Engineering Soils Manuals.

MODERN APPROACH TO LOCAL TRANSPORTATION PROBLEMS

BOB GLENN

The Great Creator, in His vast wisdom, has seen fit to keep an opaque curtain between us and the future. We know not what will happen next year, next month, week, day, or moment. Undoubtedly, this is as it should be for, otherwise, much unhappiness would exist thus defeating what is believed to be everyone's prime objective in life—

that for which we all live—happiness. By not knowing what is before us we can only anticipate and predict or prognosticate.

Anticipation is a great thing. Someone has said that it is greater than realization. As an example of the latter, we need but recall the period preceding the annual spring opening of the fishing season. Prediction or prognostication is a prerogative of every individual. We all do it and anticipate the occasions when we can say, "I told you so."

Even though this curtain shutting us off from the future is the work of the Great Creator, all of us, many of whom are devout individuals, are continually trying to cut holes in it and peer through to see what is on the other side. Possibly there may be some logic involved in answer to the question as to whether we may be cheating just a little by attempting to break through this curtain which was not of our making. Cheating or not, we continue to attempt to peer into the future. We anticipate and predict. Engineers predict by plotting "known" points of the past, developing curves showing trends and extrapolating these curves on a time basis. Highway engineers are especially prone to prediction in their professional work, and such is necessary if reliable service be rendered.

There are myriads of things, such as transportation, which affect our lives and have to do with progress of civilization, all of which change from time to time, yet for which trends have been developed. In government we have had the New Deal, the Square Deal, the Fair Deal, and the same Old Deal. With respect to styles, in Colonial days men wore wigs and women wore hoop skirts. The gay nineties saw mustaches and derby hats on men and bustles on women. After the turn of the century, pegtop trousers were the style for men and long, form-fitting dresses for the ladies. Later, in the early twenties, fabrics must have been scarce for trousers were tight and ladies dresses were such as to cause little strain on man's imagination. Now, the ladies have pedal pushers for play and the Dior look for social affairs. Even in these categories there are definite trends. However, I am happy that it is not my responsibility to extrapolate governmental or style curves.

In transportation, a field with which this group is familiar from the professional standpoint, since the invention of the wheel and within the last couple of centuries, we have experienced the invention and development of the steamboat, the railroads, the motor vehicle, and the airplane. These represent overlapping periods in history, but each could be outlined to show their respective influences on civilization. Without these transportation facilities our standard of living, the yardstick by which progress in civilization is measured, would have been below that which we experience and enjoy today.

Previous to the last decade or so, the highway engineer apparently was concerned only with current needs of the day and thus gave little thought to the future. As a result the highway situation became rather worse than better, at first gradually and in recent years at an accelerated rate.

It has been just recently that the highway engineer has attempted to look through the curtain into the future, and it would seem that his eyesight on occasion has not been of the best. He either failed to see far enough, or did not believe what he saw. Or, if these two senses were unimpaired, it would seem that he failed to do his duty. Many of us claim that we could see the present muddle coming, but were unable to convince the moneychanger of the need for action. It is evident that we are now in a mess. Someone has been or is responsible for the situation. The highway engineer's conscience could feel a little guilty.

The trouble is that the situation has almost gotten out of hand. With 58 million vehicles registered today, and 85 or 90 million motor vehicles confronting him 20 years hence, the highway engineer's ability is taxed to cope with currênt needs, to say nothing of planning and building for the future. Yet he must do both. He cannot afford to be caught asleep at the switch again.

We are all aware of the basic problem—too many vehicles for available facilities and insufficient funds to provide the facilities (roadway and parking) to satisfy the demands of the motoring public. As previous speakers on this program have indicated, funds for relieving the situation may be available presently. But let us not be disillusioned to the extent of thinking that our transportation problems will vanish even with these anticipated funds at our disposal. It is an accepted prediction that we are going to have some 85 or 90 million vehicles on our traffic ways in 20 years. This is an increase of 50% over present registration. Obviously, we are not going to have 50% more area on which to operate these vehicles, even in the urban areas where congestion is increasing daily.

Consider the Bay Bridge in San Francisco. This bridge built less than 20 years ago and designed for 72,000 vehicles per day, is now carrying over 100,000 in a 24-hour period, with the potential volume mounting daily. Los Angeles, at present, has more miles of motor vehicle transportation facilities of toll road standards, but without toll gates, than any other city. On one eight-lane section of the Hollywood Freeway over 160,000 vehicles were observed to pass in a 24-hour period but a matter of months after it was opened.

Recently I drove from Hollywood to downtown Los Angeles during the evening rush hour, and for observation purposes chose to drive the Freeway. My average speed on this most modern facility was less than 10 miles per hour and, I call to your attention, I was going in the direction of lighter traffic flow.

When it is realized that these modern facilities being added rapidly to our highway system at a cost of millions of dollars per mile, upon being opened to traffic are immediately loaded beyond designed capacity from an ever increasing reservoir of vehicles, it would seem that our highway transportation problems may be with us for some time to come.

Not all of you in the audience are confronted with problems of the magnitude of the examples just cited. However, with the current and anticipated immigration to the Northwest, each community is confronted with problems of relative local importance. What, then, should be the approach to these local problems?

First, where is the line of demarcation between local problems and those which, under certain circumstances, seem to extend beyond local boundaries or interests? Because most of us, consciously or otherwise, think of this line as drawn on the basis of jurisdiction or level of government, I shall confine my discussion to some of the things which the progressive county or city engineers are doing in their attempts to realize the most service from the transportation dollar.

Sufficiency studies

Many street and highway improvements in the past have been and, unfortunately, many still are, selected on the basis of opinion or political expediency rather than upon facts related to need, cost, and benefits. As a result, many highway dollars have been spent where maximum returns are not realized from the investment. The idea of making sufficiency studies of highway systems at the local level is demanding much interest, especially among the counties. While the various patterns developed for the studies already made or now under way may not be applicable to every county or city, certainly the application of any method whereby relative needs may be measured by a common yardstick would be a progressive step in street or highway administration.

I was interested in Mr. Gray's presentation this morning on how he developed his long-range road program for Umatilla County. While Mr. Gray undoubtedly would have liked to have made a more elaborate and detailed study whereby he could have measured his road system needs more precisely, he is to be congratulated, not only on doing a good job at an exceptionally low cost, but on his original approach to the solution of an old problem.

Last year, Kings County, California, made a County Road and Bridge Adequacy and Improvement Priority Study under the direction of their Road Commissioner, Harold E. Carlson, on which a 5-year improvement program was based. So far as I know, this is the first factual approach toward a long-range county road improvement program where all pertinent factors were taken into account. This study has already received national recognition and is recommended for your study if you are not already acquainted with it. His report to the Highway Research Board and paper presented at the ARBA meeting in New Orleans in January soon will be available upon request.

Uniform county road and subdivision standards

When one considers the similarity of purpose and of problems of county engineers, it is remarkable that so few counties or groups of counties have adopted uniform road standards. It is not unexpected that uniform subdivision standards have received little consideration because it is only recently that subdivision development has become a major industry in the West, and because problems pertaining thereto vary in the different areas. Nevertheless, it is essential that the overall plan for, and the construction of the public facilities pertaining to these new developments be controlled through engineering standards. Otherwise, they are destined to become a headache for the engineer and a tax burden on the public.

The counties of Washington are to be commended for having taken the lead on the West Coast relative to adopting uniform county road standards. The County Engineers Association of California has, within the last two years, adopted similar uniform standards, including street standards for subdivisions. The latter in conjunction with the Public Works Section of the League of California Cities. These standards have been of immeasurable benefit to the county and city engineers since their adoption.

In a recent survey of county road deficiencies in California, instigated by the state legislature, these standards provided the common base or yardstick whereby relative needs of the various counties could be determined. If adhered to, uniform design standards assure uniform standards of construction to the end that greatest efficiency may be obtained from the construction dollar. Standards which are based upon group judgment and experience are of special benefit to the young engineer, not only as a basis for design, but by way of supporting recommendations to his board or council. Obviously, accepted standards, uniform or otherwise, are necessary as a base for sufficiency studies such as previously mentioned. These are but a few of the advantages of uniform standards for road and street construction. There are apparently no disadvantages.

Materials testing

A county road or city street is relatively as important to the county or city as a section of state highway is to the state. Yet we find many county roads and city streets being designed and constructed without any factual knowledge of the subbase or materials to be used. On the other hand, state highway engineers make exhaustive studies to obtain this basic information. Can it be that these city and county engineers possess super ability or judgment? It has been my observation that the progressive and more successful engineers are taking advantage of modern methods for determining the suitability of materials for road building and designing the structure accordingly.

It is realized that it may not be feasible for many of the smaller political subdivisions to each have facilities for testing road materials. Also, that our state highway laboratories may not be in a position to make such service available when needed, or that a commercial laboratory may not be convenient. Perhaps the answer may be in the cooperative materials laboratory idea which is being investigated by a committee of the County Engineers Association of California, and about which a report has just recently been issued in printed form. While this report pertains primarily to the situation in California, the general principles involved would apply to any area. Within limits I could, upon request, furnish those interested with a copy of this report from the limited supply in my office. The basic idea behind this study was that two or more counties and/or cities could build, equip, and operate a cooperative laboratory to economical advantage and convenience. It would seem that the idea may, in some instances, have merit.

Urban transportation studies

Of possible major interest to the city engineers is the new look at urban transportation problems. We are all aware of current methods of obtaining and analyzing data pertaining to the transportation of people and goods in and through urban areas. There is evidence in the minds of some people that the information being obtained may not be the proper basis for making long-range plans with respect to urban development. It is thought that perhaps the basis should not be on results of O. and D. studies, but on such as potential or controlled land use. Consequently, there recently has been established the National Committee on Urban Transportation for the purpose of taking a new look at the urban transportation picture and with the hope that the committee may come up with what fundamental information is needed, proper and uniform methods of obtaining corresponding data, and how to analyze same. Norman Kennedy, an Oregon State College graduate, has been named staff director for this work and is now on leave from the Institute of Transportation and Traffic Engineering of the University of California to act in that capacity.

The membership of this committee is composed of representatives from the seven major national and international associations having mutual interests in the study, and the U.S. Bureau of Public Roads. In addition to some six consultants of national repute, there are nine subcommittees with a total membership of some 130 individuals, each of whom has been selected on the basis of geographical representation and professional ability. Incidentally, I believe I am not betraying any confidence by stating that the committee is planning to make a pilot study in San Diego in the near future. It would seem that we may justly anticipate new developments in line with the purpose for which this committee was established.

Operation of traffic facilities

With the ever increasing number of motor vehicles, with resulting congestion and added exposure to hazards, operational problems are mounting. Here, again, perhaps we should follow somewhat the proven methods and principles used by our state highway departments and larger cities in attacking these problems. Ralph Dorsey, while traffic engineer for Los Angeles (recently retired), once said that there were 50 million traffic engineers in the United States, but less than a thousand of them paid dues to the Institute of Traffic Engineers and that some 3 million of them lived in Los Angeles. Unfortunately, the situation is much as that to which Mr. Dorsey referred. Traffic problems can and should be solved on fundamental principles of traffic engineering, yet how often we find traffic regulations based upon political expediency or what may be worse, the snap judgment of individuals, otherwise intelligent, but absolutely ignorant of modern methods of approaching the traffic problem. The adverse economic effect of inefficient traffic regulation may be endured, but we should not condone that which unnecessarily endangers the lives of our citizens.

Time does not permit the discussion of modern methods for solution of traffic problems. Suffice to say that such methods exist and it should be the responsibility of the city or county engineer to acquaint himself thereof and to solve the local traffic problems accordingly. The solution to the problem is usually not difficult. Difficulty arises from non-acceptance by the public of regulations imposed. Regarding the latter, local traffic safety commissions have been, in many instances, very successful. Personnel of such committees usually include a representative of the local governing body, police and engineering departments, Parent Teachers Association, and local citizens.

A committee of this nature should be of great assistance to the engineer in that it can bring into focus the various interests and viewpoints of the groups represented, prevent him from getting too technical and, above all, it acts as a buffer or liaison agent between the engineer and the public. Also, with proper publicity to the effect that any proposed project or program has the sanction of such committee, public acceptance is greatly enhanced.

Finally, may I say that I have not presumed to tell you anything you did not already know. We are all aware that national brands of cigarettes are available at every corner store, yet week after week we are reminded through various means of communication of their individual qualities. Apparently this is the way to sell cigarettes. Perhaps through repeated reminders of how we may best approach our local transportation problems we may be of added service to our public.

ADVISORY COMMITTEE

W. A. Bugge, Director
Department of Highways
Olympia, Washington

John W. Cattrall
County and City Relations Engineer
Oregon State Highway Commission
Highway Office Building
Salem, Oregon

Fred J. Dixon
District Engineer
U.S. Bureau of Public Roads
Olympia, Washington

R. G. Hennes
Department of Civil Engineering
University of Washington
Seattle 5, Washington

Fred Lordan
Highway Research Council of Washington
504 Arctic Building
Seattle 4, Washington

B. J. McClarty, Secondary Roads Engineer
Bureau of Public Roads Division Eight
P.O. Box 3900
Portland 8, Oregon

R. S. Milln
Clackamas County Engineer
Room 204 Courthouse
Oregon City, Oregon

Professor Emmett Moore, Chairman
Department of Civil Engineering
State College of Washington
Pullman, Washington

F. L. Phipps, Executive Secretary
Association of Oregon Counties
The Dalles, Oregon

Paul B. Rynning, Secretary-Treasurer
Association of County Engineers of Oregon
Courthouse
Medford, Oregon

M. A. Westling
Planning and Public Works Consultant
Bureau of Municipal Research
University of Oregon
Eugene, Oregon

Joshua H. Vogel
Planning and Public Works Consultant
Association of Washington Cities
250 Smith Hall, University of Washington
Seattle 5, Washington

STUDENT COMMITTEE

Gordon Wyatt, General Chairman

Samuel Christensen
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STUDENT CHAPTER OFFICERS ASCE

Marvin Stephenson, President
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Roger Menke, Secretary
Gordon Wyatt, Treasurer

REGISTRATION ROSTER

CITY OFFICIALS

Name	*Position*	*Organization*	*Address*
Allen, Don	Assistant City Engineer	City of Eugene	2975 Kincaid
Anderson, Frank A.	Assistant City Engineer	City of Coos Bay	P. O. Box 218
Anderson, R. G.	Construction Engineer	Public Works	840 S. Trofon Tacoma, Wash.
Briggs, J. Allen	Council Member	City of Empire	169 Wallace
Burr, George F.	Mayor	City of Coquille	Coquille, Ore.
Burton, E. K.	City Engineer	City of Ontario	577 NW 3d
Carstensen, Robert	Assistant City Engineer	City of Grants Pass	1006 Lawnridge
Chapman, Archie	Assistant Engineer	City of Salem	City Hall
Cruden, Ray N.	City Engineer	City of Oswego	40 A Avenue
Davis, J. H.	City Engineer	City of Salem	City Hall
Derrick, Herb	Public Works Superintendent	City of Ontario	921 SW 1st
Dickinson, Edmund J.	Airport Manager	City of Pendleton	City Hall
Fitzpatrick, J. F.	Assistant City Engineer	City of Salem	City Hall
Fronzen, J. L.	City Manager	City of Salem	City Hall
French, Archie	City Engineer	City of Pendleton	700 NW 6th
Goebel, Ray W.	City Engineer	Eugene Water & Electric Board	400 E. 4th
Goodnight, V. L.	City Engineer	City of Corvallis	City Hall
Heller, J. A.	Street Superintendent	City of Empire	City Hall
Henderson, E. F.	Councilman	City of Empire	1278 Michigan
Henriot, C. E.	Chief, Maintenance Div., PWD	Public Works	1215 N. K Tacoma, Wash.
Herrington, Bob	City Engineer	City of North Bend	City Hall
Huddleston, Mike	City Engineer	City of Coquille	1096 W. 11th
Hughes, Earl R.	Street Superintendent	City of Oswego	805 10th
Klein, Andrew	City Engineer	City of Forest Grove	2302 13th
Laurila, J. L., Jr.	Assistant Engineer	City of Eugene	City Hall
Loosley, John	City Engineer	City of Roseburg	City Hall
McClain, E. C.	Street Superintendent	City of Lebanon	1552 2nd
Meng, Kenneth A.	Assistant City Engineer	City of Roseburg	520 Bellview
Mullins, W. J.	Street Superintendent	City of Eugene	175 Madison
Olsvick, H. M.	City Engineer	City of Astoria	Astoria, Ore.
Palmer, E. F.	Superintendent of Public Works	City of Hermiston	1209 W. 7th
Puddy, Hal	City Engineer	City of Hood River	Rt. 4, Box 57
Rear, Alfred A.	City Manager	City of Reedsport	2634 Park Court
Reiter, C. E.	City Manager	City of Albany	P.O. Box 490
Roeber, Roland J.	Design—Public Works	Public Works	5207 S. M Tacoma, Wash.
Thompson, Lester	Street Superintendent	City of Corvallis	124 N. 7th
Uhrhammer, Frank	Street Superintendent	City of Albany	333 Cleveland
Van Wormer, B. T.	Assistant City Engineer	City of North Bend	1362 Vermont
Vlett, G. W.	City Engineer	City of Albany	950 W. 18th
Waggener, C. L.	City Engineer	City of Pullman, Wash..	305 Aith
Wall, Homer S.	City Engineer	City of The Dalles	420 W. 2nd
Wine, Joe	Inspector	City of Albany	Rt. 4, Box 387

COMMERCIAL REPRESENTATIVES

Name	*Position*	*Organization*	*Address*
Ambuhl, M. R.	Division Sales Engineer	Armco Drainage & Metal Products	2321 SE Gladstone Portland, Ore.
Andrus, Steve	Sales Engineer	Pope & Talbot, Inc.	3070 NW Front Portland, Ore.
Blee, K.R.	Asphalt Manager	Shell Oil Company	1220 SW Morrison Portland, Ore.

REGISTRATION ROSTER—*Continued*

Congdon , R. G.	Sales	American Bitumuls & Asphalt Co.	5501 NW Front Portland, Ore.
Craig, C. F.	Civil Engineer	J. H. Baxter Co.	541 Pittock Block Portland, Ore.
Dorman, Robert C.		Timber Structures, Inc.	7085 N Woolsey Portland, Ore.
Ebersolt, Robert B.	Manager	Interstate Tractor & Equipment Co.	2355 Silverton Road Salem, Ore.
Ferguson, C. H.	Registered Engineer	Prepakt Concrete Co.	300 12th Seattle, Wash.
Hague, George	Sales Engineer	American Bitumuls & Asphalt Co.	849 Pleasant Street Walla Walla, Wash.
Hamson, George	Sales	Columbia Equipment Co.	1240 SE 12th Portland, Ore.
Hector, Wally M.	Sales Manager	Douglas Oil Co.	5500 NW Front Portland, Ore.
Henry, Ted	Manager	Asphalt Equipment Co.	1136 NE 114th Portland, Ore.
Hunsperger, W. L.		Traffic Safety Supply Co.	2636 NE Sandy Portland, Ore.
Jessup, O. C.	President	Contractors Equipment Corp.	2727 SE Union Portland, Ore.
Lindsley, Dan L.	District Manager	Wood-Treating Chemical Co.	518 Public Service Bldg Portland, Ore.
Luckeroth, Paul R.	Sales	Pope & Talbot, Inc.	3070 NW Front Portland, Ore.
Martin, William C.	Sales Engineer	Shell Oil Company	3026 NE 20th Portland , Ore.
Murray, Ray A.	Sales Manager	Ideal Portland Cement Co.	309 Lumbermen's Bldg Portland, Ore.
Ritter, Glen L.	District Manager	American Bitumuls & Asphalt Co.	PO Box 489 Portland, Ore.
Ronkel, Bert	Manager, Long Bell Treating Co.	Long Bell Lumber Co.	Longview, Wash.
Salquist, L. W.	Pacific Coast Manager	Chapman Chemical Co.	1238 NW Glisan Portland, Ore.
Schriver, George W.	Sales Manager	Cramer Machinery Co.	7617 SW Hood Portland, Ore.
Schroeder, Arthur W.	District Engineer	Armco Drainage & Metal Products	Box 263 Walla Walla, Wash.
Shurtz, Al	President	Asphalt Equipment Co., Inc.	3929 Buell Drive Fort Wayne, Indiana
Sykes, Allan H.		Shell Oil Company	1219 Westlake, N Seattle, Wash.
Wallen, Bob B.	Sales Engineer	American Bitumuls & Asphalt Co.	2036 28th Street Milwaukie, Ore.
Wimberly, Cliff	Sales Engineer	American Bitumuls & Asphalt Co.	295 Rural Salem, Ore.

CONSULTANTS AND SERVICE BUREAU REPRESENTATIVES

Name	*Position*	*Organization*	*Address*
Bond, W. R.	Western Manager	Service Bureau, AWPA	1410 SW Morrison Portland, Ore.
Finn, Fred N.	District Engineer	The Asphalt Institute	317 Forum Bldg. Sacramento, Calif.
Howard, Frank Z.	Consultant	Self	1155 Lakeshore Drive Klamath Falls, Ore.
Quiner, John H.	Consulting Engineer	Self	1542 Washington St. Eugene, Ore.

REGISTRATION ROSTER—*Continued*

Ryker, Rodney P.	District Engineer	The Asphalt Institute	4432 White Henry Stuart Bldg., Seattle, Wash.
Schuster, Gilbert M.	Paving Engineer	Portland Cement Association	125 H Street, SE Auburn, Wash.
Vallerga, B. A.	Managing Engineer, Pacific Coast Division	The Asphalt Institute	Russ Bldg. San Francisco, Calif.
Waller, Arthur C.	Consulting Engineer	Self	8258 15th, NE Seattle, Wash.
Ward, George	Civil Engineer	West Coast Lumbermen's Assoc.	1410 SW Morrison Portland, Ore.

CONTRACTORS

Amort, A. A.	Manager, Alaska Asphalt Co.	Rogers & Babler	Rt 2, Box 173 McMinnville, Ore.
Aubry, Bert B.	Vice President	McNesby & Aubry	Box 85, Corvallis, Ore.
Colvin, V. H.	Superintendent	Warren Northwest. Inc.	4th St, Salem, Ore.
Critchett, K. E.	Estimator	Diesel Oil Sales Co.	16719 2d, NE Seattle , Wash.
Cushing, B. F.	Partner	Cushing Brothers	1853 N. Capitol Salem, Ore.
Cushing, John A.	Partner	Cushing Brothers	149 Court Salem, Ore.
Gallagher, Donald A.	Superintendent	Corvallis Sand & Gravel	Box 691, Corvallis, Ore.
Gallagher, John H.	Manager	Corvallis Sand & Gravel	Box 691, Corvallis, Ore.
Gramatky, F. Gunner	Contractor	Self	4849 Hazelwood Ave Carmichael, Calif.
Hanna, W. P.	Superintendent	Northwest Asphalt Co.	7343 E H Marginal Way Seattle, Wash.
Head, W.W.	Superintendent	Warren-Northwest, Inc.	610 Vista Ave Salem, Ore.
Lindahl, George A.	Partner	Central PavingCo.	590 Monmouth Independence, Ore.
Page, Emerson B.	Partner	Central PavingCo.	Box 127 Independence, Ore.
Woodward, G. W.	Self	Woodward & Son, Construction	910 Knott Coquille, Ore.

COUNTY OFFICIALS

Bertsch, William L.	Assistant County Engineer	Douglas County	302 Leland Ave Roseburg, Ore.
Carter, A. D.	Assistant County Engineer	Kitsap County	Rt. 1, Box 88 Olalla, Wash.
Cherson, C. F.	County Roadmaster	County Road Dept	Odell, Ore.
Conway, Harry E.	Assistant Construction Engineer	Multnomah County	3233 NE 13th Portland, Ore.
Fauerso, C. B.	County Engineer	Josephine County	1097 Ashley Place Grants Pass, Ore.
Graham, A. D.	County Surveyor	Marion County	Courthouse, Salem, Ore.
Gray, John R.	County Engineer—Roadmaster	Umatilla County Road Dept.	Box 667, Pendleton, Ore.
Hanson, Curtis G.	County Surveyor	Benton County	Courthouse, Corvallis, Ore.
Harmon, William G.	Transitman	Lane County	Courthouse, Eugene, Ore.
Irving, Ben B.	County Surveyor	Douglas County	906 Military, Roseburg, Ore.
Jacob, Glenn	County Engineer	Yamhill County	Box 32, McMinnville, Ore.
Kelley, R. H.	County Commissioner	Umatilla County	616 NW Bailey Pendleton, Ore.
Kruse, Fred A.	County Commissioner	Coos County	2675 Stanton St North Bend, Ore.

REGISTRATION ROSTER—*Continued*

Kvenzi, Theodore	Assistant County Engineer	Marion County	Rt. 2, Box 193B Silverton, Ore.
Larsen, Walter W.	County Engineer	Linn County	1082 W. 8th, Albany, Ore.
Martell, C. S.	Assistant Roadmaster	Coos County	765 State, North Bend, Ore.
Nelson, M. R.	Construction Engineer	Multnomah County Road Dept.	1709 SE 46th Portland, Ore.
Norberg, Oscar H.	County Engineer	Lane County	1949 W. 18th, Eugene, Ore.
Pattison, JohnH.	County Engineer	Kitsap County	Port Orchard, Wash.
Perkins , Mart C.	County Engineer	Hood River County	Rt. 3, Box 182 Hood River, Ore.
Robb, Floyd A.	County Engineer	Coos County Road Dept.	254 N. Dean, Coquille, Ore.
Rynning, Paul B.	County Engineer	Jackson County	Courthouse, Medford, Ore.
Stancer, William A.	County Engineer	Pierce County	510 Courthouse Tacoma, Wash.
True, F. C.	County Commissioner	Coos County	4th St., Coquille, Ore.

FEDERAL REPRESENTATIVES

Name	*Position*	*Organization*	*Address*
McClarty, B. J.	Div. Secondary Roads Engineering	Bureau of Public Roads	6535 N. Fenwick Portland, Ore.

OREGON STATE COLLEGE

Coopey, Martin P.	Prof. Civil Engineering	Oregon State College	Corvallis, Ore.
Gleeson, G. W.	Dean of Engineering	Oregon State College	Corvallis, Ore.
Gray, James L.	Asst. Prof. General Engineering	Oregon State College	Corvallis, Ore.
Kofoid, Orville	Prof. Civil Engineering	Oregon State College	Corvallis, Ore.
Leonard, T. E.	Instructor, Civil Engineering	Oregon State College	Corvallis, Ore.
Popovich, M.	Asst. Dean of Engineering	Engineering Experiment Station	Oregon State College Corvallis, Ore.

STATE OF OREGON

Ayers, H. C.	Field Engineer	State Highway Commission	555 N. Winter Salem, Ore.
Baldock, R. H.	Highway Engineer	State Highway Dept.	State Highway Bldg. Salem, Ore.
Blensly, R. C.	Acting Planning Survey Engineer	State Highway Dept.	Salem, Ore.
Cattrall, John W.	Engineer, County & City Relations	State Highway Dept.	Salem, Ore.
Crandall, F. B.	Traffic Engineer	State Highway Dept.	Salem, Ore.
Hagemann, John F.	Asst. County City Engineer	State Highway Dept. Relations	473 Manbrin Drive Salem, Ore.
Head, J. A.	Asst. Traffic Engineer	State Highway Dept.	Salem, Ore.
Hill, W. C.	Soils Engineer	State Highway Dept.	Salem, Ore.
Jones, Vern R.	Civil Engineer	State Highway Dept.	680 Wildwind Drive Salem, Ore.
Lammers, C. G.	Asst. Cost Analyst	State Highway Dept.	1825 N. Summer Salem, Ore.
Layton, C. E.		State Highway Dept.	3640 Osborn, Salem, Ore.
Moehring, David	Resident Engineer	State Highway Dept.	Rt. 1, Box 125 Corvallis, Ore.

REGISTRATION ROSTER—*Continued*

Schwarz, G. Robert	Bridge Inspector	State Highway Dept.	828 N. 12th Corvallis, Ore.
Sturgis, Harry R.	Asst. Cost Analyst	State Highway Dept.	Salem, Ore.
Sugret, Fred W.	Asst. Cost Analyst	State Highway Dept.	Salem, Ore.
White, Oscar A.	Asst. Engineer, Materials	State Highway Dept.	Salem, Ore.
Widdows, W. O.	Asst. Maintenance Engineer	State Highway Dept.	Salem, Ore.

STATE OF WASHINGTON

Bailey, W. A.	District Construction Engineer	Dept. of Highways	401 W. 29th Vancouver, Wash.
Bugge, W. A.	Director of Highways	Dept. of Highways	Olympia, Wash.
Collier, Ira L.	Assistant Engineer	Wash. Highway Dept.	Botherll, Wash.
Gallagher, J. A. Jr.	District Traffic Engineer	Wash. Highway Dept.	4200 Main St. Vancouver, Wash.
Hansen, Julia Butler	State Representative	Washington Legislature	Olympia, Wash.
Hensel, R. E.	Highway Commissioner	Wash. State Highway Commission	Rt. 1, Box 1750 Bremerton, Wash.
McKay, Paul J.	District Engineer	Dept. of Highways	Box 90, Vancouver, Wash.
McKibben, W. E.	Assistant Construction Engineer	Dept. of Highways	3314 S. Quince Olympia, Wash.
Minor, Carl E.	Materials & Research Engineer	Dept. of Highways	3415 S. Quince Olympia, Wash.
Stackhouse, J. L.	Maintenance Engineer	Dept. of Highways	Transportation Bldg. Olympia, Wash.
Stein, Donald E.	Assistant Construction Engineer	Dept. of Highways	3617 S. Quince Olympia, Wash.
Trotland, D. W.	District Soil Engineer	Dept. of Highways	4200 Main St. Vancouver, Wash.

UNIVERSITY OF CALIFORNIA

Name	*Position*	*Organization*	*Address*
Glenn, Bob	Engineering & Extension Representative	University of California	Berkeley, California

UNIVERSITY OF OREGON

Westling, A. M.	Public Works Consultant	Bureau of Municipal Research & Service	University of Oregon Eugene, Oregon

UNIVERSITY OF WASHINGTON

Hennes, R. G.	Prof., Civil Engineering	University of Washington	3811 41st, NE Seattle, Wash.

WASHINGTON STATE COLLEGE

Ericson, Elvin G.	Asst. Prof., Civil Engineering	Washington State College	703 Jackson Pullman, Wash.
McLerran, James H.	Highway Research	Washington State College	1820 Creston Lane Pullman, Wash.
Riedesel, G. A.	Research Engineer	Washington State College	159 Elb, Pullman, Wash.
Turner, Robert S.	Highway Research Engineer	Washington State College	410 Dilke, Pullman, Wash.

REGISTRATION ROSTER—*Continued*

UNCLASSIFIED

Giddings, Ray	Field Engineer	Pittsburgh Testing Lab.	Box 4382, Portland, Ore.
Goff, Vyrl D.	District Manager	Pittsburgh Testing Lab.	1870 SE 113th Portland, Oregon
McKenzie, Malcolm	Instructor, Civil Engineering	St. Martin's College	610 North St. Olympia, Wash.
Ostergren, Ben F.	Division Managing Director	American Road Builders' Assn.	World Center Bldg. Washington, D. C.
Peters, Art	Student	St. Martin's College	1076 Adams Olympia, Wash.
Poorman, John M.	Vice President	Kenneth Poorman Co.	1835 SE Grand Portland, Ore.
Stevens, Cecil	Vice President	Arrow Transportation Co.	3125 NW 35th Portland, Ore.
Thomas, Morgan A.	Assistant Editor	Pacific Builder & Engineer	2418 3d, Seattle, Wash.

LIST OF PUBLICATIONS

ENGINEERING EXPERIMENT STATION
OREGON STATE COLLEGE
CORVALLIS, OREGON

Bulletins—

No. 1. Preliminary Report on the Control of Stream Pollution in Oregon, by C. V. Langton and H. S. Rogers. 1929. 15 cents.

No. 2. A Sanitary Survey of the Willamette Valley, by H. S. Rogers, C. A. Mockmore, and C. D. Adams. 1930. 40 cents.

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