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ENGINEERING EXPERIMENT STATION
OREGON STATE UNIVERSITY
CORVALLIS, OREGON

Proceedings of the 1962 Northwest Roads and Street Conference

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OREGON STATE ENGINEERING EXPERIMENT STATION,

CORVALLIS, OREGON

Proceedings of the 1962 NORTHWEST ROADS AND STREET CONFERENCE

Corvallis, Oregon
February 7-9, 1962

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Engineering Experiment Station
Oregon State University
Corvallis, Oregon

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1962 NORTHWEST ROADS AND STREETS
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Bureau of Public Roads
Portland, Oregon
Presiding

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FORREST COOPER
Deputy State Highway Engineer, Oregon
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Director of Highways
Olympia, Washington
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Traffic Engineer
Oregon State Highway Department
Moderator

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WILLIAM A. BOWES
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Presiding

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ACCIDENT RECORDS. D. W. Schoppert, Highway Transport Engineer, Automotive Safety, Washington, D. C.

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SAFE DRIVING HABITS. Walter C. Lunsford, Western Regional Representative, Auto-Industries Highway Safety Committee, Washington, D. C.

FRIDAY, FEBRUARY 9

Forenoon

JOHN A. ANDERSON
Marion County Engineer
Presiding

9:00 NATIONAL ASSOCIATION OF COUNTY ENGINEERS MANUALS

COUNTY ROAD MANAGEMENT, C. Arthur Elliot, National President, National Assn of County Engineers, Greene County, Iowa.

Discussion: Pat Thompson, Franklin County Engineer, Washington; Jack Kalinoski, Klamath County Engineer, Oregon.

11:00 AASHO ROAD TEST. William N. Carey, Jr, Chief Engineer for Research, AASHO Road Test, Ottawa, Illinois.

END RESULT SPECIFICATIONS
Contractor's Viewpoint

John C. Compton

End result is something we are hearing about more and more, although something rather new to me. I had always thought it was up to the contracting agency to worry about the end result and the contractor to worry about getting the work done the way the engineer wanted it done.

In the last year I have been studying the end result type of contracting and find that it is far from being new. To me it seems the better way for both the contractor and the contracting agencies. I make this statement with reservation, for in some cases end result methods can be carried to the extreme. I believe, however, that at the present time we have carried the unit price method to the extreme.

To explain myself, let me cite an example. Say that a job was advertised for bid and the following was the total wording for the general and special provisions:

> To be built, one paved road, four lane, each eleven feet wide, eight-foot shoulders, and five miles long, on such and such predetermined grade and center line. Of such quality that it will last for ten years.

Obviously, this is an absurd example and allows too much latitude for the contractor to be responsible for, and I am sure the contracting agency, for their purposes, would think so too. On the other hand, take the specifications which spell out for the contractor not only how he is to do the work, but the equipment he is to use. With the use of a unit price for every item, almost anyone who can obtain a bond is in a position to look over a respectable contractor's bid price and thereby undercut him on his prices in succeeding bids. These men may have had no previous experience and many times do not have the necessary skill. Perhaps for the advantage of lower prices this is the kind of contractor the contracting agencies want, but I rather doubt it. A bona fide contractor takes pride in his workmanship and has a sense of accomplishment. Many times this is hard to achieve because the prices are cut down and the contractors are looking for survival.

What I am trying to point out is that I feel that somewhere between the extreme method of end result and the extreme unit price method now being used, there is a better way of doing construction work.

If contracts were to be let with more lump sum bids, or near lump sum bids, each project could be bid according to the individual problems one would anticipate. This would prevent the inexperienced contractors from relying on a history of unit prices upon which to base their bid, without regard to specific job conditions and current construction cost information. Bidding from past history of unit prices, without experience, is bad for the industry. Any attempt to get work on this basis can only result in low unrealistic prices.

With the lump sum bidding system, workable specifications that could be followed would have to be provided. The resident engineer should have the authority he needs to properly inspect the work and make any necessary field changes without impeding progress and production. More general specifications would provide less opportunity for disagreement between the contractor and the engineer, and it would seem that this would thereby result in fewer claims.

The specifications can be written for end results. Take for example our state. In bidding on structures we have the lump sum bids, which have been a step in the right direction. Also, the Louisiana Standard Specifications for Compaction of Embankments reads as follows:

> Compaction of embankments shall be accomplished by any satisfactory method that will obtain the density hereinafter specified, unless a specific method is provided by special provisions.

There are also places where a change could be made. For example, many agencies have a liquid limit test and a minimum fracture requirement on aggregates produced, but still require you to scalp the raw material. Whether the material has to be scalped or not depends on the liquid limit and fracture tests.

Still another example is the compaction of base rock. A certain density is required. Instead of letting the contractor choose his own method of meeting the compaction requirements, special tools of a certain design also are required.

The lump sum bidding method could relieve some checkers, which could result in less engineering expense, or possibly more time for inspecting and testing. Better testing procedures and methods should be provided that will prove the quality of the work as it is accomplished without limiting in any way the contractor's ability to maintain high production with good, modern equipment and methods.

The lump sum specification, once written, would not have to be changed to keep abreast of each new development in methods or equipment. The contractors, equipment manufacturers and material suppliers would be encouraged to put their best efforts into developing methods and machinery to expedite the work, rather than to meet a single specification or individual idea of how the work should be performed. This would, I am sure, lead to better quality work at less cost.

I can visualize that the end result methods would be a great help to the contractor in solving job financing problems. When one item was completed it would mean a major phase of the contract was completed, and the retained percentage on that item could be released. Methods for releasing contract retainage have improved greatly over the last few years. I believe, however, I am safe in saying that both contractors and engineers realize that this is still a problem in view of the accelerated construction era we are now in.

If the end result methods were followed, the contractors would be put on a more professional basis since the bidding and performance requirements would have to be more thorough, thus eliminating the fly-by-night bids and inexperienced bidders. What the contractor wants is to put construction back on a more professional basis, to take pride in his workmanship, have the responsibility for the work, and be permitted to use his own ingenuity and ability as much as possible.

It can be said that much progress has been made in the field of specifications and construction methods. I think we all realize that we are not as yet perfect, that there is still much room for improvement. It is our responsibility as contractors and engineers to be constantly improving our methods and to keep up with the times. Perhaps the end result method is the answer to our present and future needs. It certainly behooves us to investigate into every possibility and glean from it all that which is to our advantage.

END RESULT SPECIFICATIONS
Engineer's Viewpoint

George N. Miles

From the viewpoint of an engineer, we see in end result specifications another forward step in the direction to which we engineers must be dedicated—improved construction at reduced cost. We see here another possibility to correct a fundamental error which is prevalent on most highway projects. Highways are usually designed with sufficient width and adequate depth, but they are always designed too short.

Certainly we are not so naive as to think that a mere change in specification writing is going to provide an answer to all the economic problems of highway construction, but we do see a possibility here and we think it should be explored to the fullest. We believe that end result specifications will put contractual bidding back on a competitive basis where the most competent organizations will prevail—that it will encourage all contracting agencies to new and better constructions methods, with new and better construction equipment. In short, within the limits of good sound construction practices, it will turn loose our contractors to do the job they are capable of doing, and the entire industry as well as the public will benefit therefrom.

The difference between what I will call standard specifications and end result specifications will be found in the restrictive clauses which usually define the ways and means that shall be used to achieve a desired result.

This is so characteristic of standard specifications. They tell you how to do the work as well as what the final result will be. There might be several better ways to accomplish this final result, but "you shall do it this way," and there is the point of conflict.

The end result specification will, within limits, simply state what the final product shall be, and this usually is accompanied by a proof test of some sort. It refers in no uncertain terms to what is expected as a final product rather than how such a result is to be accomplished. The end result specification will often describe the basic elements necessary to success in any given item of work, but will not dwell on or require such item of work to be done in a given fashion. It will go into much detail, however, concerning the acceptability of the final product. It does not restrict the contractor to the same old routines but encourages him to use his own ingenuity, making best use of his own organization and equipment in accomplishing the final product. It promotes new methods and new thinking, yet does not forbid the tried and true ways.

Colorado has been cited as a state operating under end result specifications and, to a limited extent, this is true. We have altered our standard specification on several items of work and other work items are revised regularly by special provisions on current project plans in order to get the experience with an end result specification before completely adopting it. We are feeling our way along and, at the same time, trying to benefit from the experience of other states that are working along the same line of thought. It would be more nearly correct to say that Colorado is dedicated to a policy of end result specifications —believes in it thoroughly, but is using it cautiously. Our limited use so far has been very successful and now meets with general approval among the contractors.

Our adoption of end result specification has been advantageous to our contractors. As an example we cite the item of embankment compaction. Formerly we attempted complete control of the compaction work. We designated type, size, weight, and speed of equipment. We also designated a minimum number of passes that this equipment would make over a given thickness of lift. The rolling equipment was bid on an hourly basis as a part of the contract—truly a force account item of work—and our engineering personnel controlled the operation 100 percent. The result was that we secured proper density but often overrolled as a matter of insuring that density and the entire function became the key operation around which the contractor tried to build his project. His earth-moving equipment was badly slowed down to the point that he was constantly looking for another location in which to work while the wetting and rolling was catching up. Good organization of the work and best use of his equipment were not quite possible. Being able to get only limited production from his equipment investment, his prices were necessarily high and he was constantly trying to increase his volume of dirtwork, often to the detriment of the wetting and rolling results.

Today, control of the entire operation is his. Under the end result specification we are out of his way. He can use rollers or vibrators or whatnot to match his own capabilities so far as earthwork volume is concerned. Other than thickness of lifts and the requirement of moisture and density, he has a green light, and we are not too technical about the thickness of the lift as long as the required moisture and density are secured. Failing in this, he gets the red light.

Today we see more and more varied compacting equipment than ever before. Better yet, we have seen a change in the attitude of the contractor's supervisory people who now care whether or not we have optimum moisture in the lift, and who are quite conversant with soil types and their various physical characteristics. We like this. Best yet, our compaction cost has decreased some 20 percent, and we think there will be further gains.

Engineering-wise, we must now speed up our own operation in order to match the volumes coming out of those scrapers and furnish immediate test results on moisture and density. This is no small problem on a multiple-shift operation. None the less, we like it.

It would seem that in the case of most public highway agencies the basic reason for contracting our actual construction work is that our construction agencies have the organization, equipment, manpower, and know-how with which to do the job we need done. Otherwise, surely we would not be hiring them. With an end result specification, we are able to give these construction agencies the latitude to develop the ways and means that each of these organizations will use in order to produce the roadways that we have hired them to build. It is actually designed for organizations that are competent, capable, and have the proper equipment or the means by which to secure the proper equipment to do the job.

Why then should it be necessary for us to advise each contractor of every step that he should take in producing any single item of work. Why not go to the end result and define it to him in terms that leave no question as to what is required, letting him choose his own ways and means of achieving this end result.

In order to make this specification work in the manner in which it is intended, it is absolutely necessary that we have complete cooperation between the project engineering staff and the contractor's supervision. In Colorado, we believe that once a contractor has risked his money as well as his reputation in competitive bidding in order to get a job, our engineering staff shall at that point become a part of the construction team composed of the engineers and the contractor's people in a mutual effort to get the best construction work at the least cost—least cost to both the State of Colorado and to the contractor. We say this because we realize that any contractor who loses money on a project or loses money steadily on a given item in several projects is going to do nothing but raise his prices in future bidding, so we feel that it behooves us as an organization to give every assistance we can in helping that contractor make money at his bid price.

In summation, may we say that this type of specification seems "tailor made" for an industry that is progressive and vigorous. Surely then, it has application in the highly competitive highway construction industry where "time is of the essence" on every project, and new and better ways and means can be used to such tremendous advantage. None of us is so far ahead in the current interstate construction program that we can sit back and rock. Furthermore, by the time the current program is completed, new traffic will have overrun many of the older roadways and bigger and better transportation facilities will again be a prime requirement to our national economy.

ADEQUATE CONSTRUCTION CONTROL
Materials

W. A. Garrison

INTRODUCTION

I think all of you will agree that those of us engaged in road building for public agencies should exercise some control of materials in the construction of our roadways. However, not all of us utilize adequate materials control in the design and construction of our roads and streets. By selecting or approving either a material or the state in which a material is placed, we exercise "control" whether or not our decision is made as a result of visual inspection, previous knowledge, laboratory tests, or a combination of these. We all know the project engineer represents the public agency, and his decisions regarding material will affect the service life and maintenance cost of a roadway.

Personal opinion is valuable. Add to this personal opinion the results of a properly conducted test and you will have the basis for a sound engineering decision. The design of a pavement is important for the same reason that the design of any other structure is important. The pavement will be expected to serve safely as a roadway for its designed life, with a minimum of cost to its owners.

In the past thirty years we have seen many changes in engineering and in all other lines of endeavor. Regardless of our occupational fields, we should look back and study what has happened in the past and change as necessary our approaches and practices to suit the period ahead.

There was a time when the competent project engineer did his own survey work, inspected the material, and supervised the placement. I am referring to that happy time when the project engineer did not have to possess the abilities of a certified public accountant. His basic control test of the compaction of a fill was proof-rolling with a loaded truck. A well placed heavy heel and the pat-stain test constituted the bulk of his tests for asphalt surfacing.

Yes, times indeed have changed. Project engineers for public agencies must maintain evidence of compliance with federal and state regulations, as well as fulfilling their obligations to this profession.

Highway engineers today are faced with the problem of planning and constructing the largest public works program in the history of the world. To meet the demands of this program, more and better tools have been developed, and others will follow. Photogrammetric mapping crowds months of field work into a few short weeks. Electronic computing devices solve earthwork and traverse problems in minutes. Industry is making great strides in the development of high capacity equipment of all kinds. Both earth-moving equipment and plant production facilities are being enlarged to keep abreast of the construction demands. The project engineer, even on city and county projects, is being engulfed by the sheer volume and speed of the work. Heavier wheel loads and increased traffic use have resulted in greater demands on the quality of our road and street pavement designs. The magnitude of truck wheel loads and the frequency of application have increased to such an extent that one of the most critical problems in the public works field is the construction of high quality roadways with the funds available.

We are faced here with discussing adequate construction materials control and its value to the project. The term "adequate materials control" refers to the two major aspects of the use of construction materials. Both of these aspects must be considered if we expect full value from the funds we spend. From a materials engineer's point of view, both the quality of the materials and the manner in which these materials are placed are of equal importance.

SPECIFICATIONS

Specifications, including the special provisions for a project, are the written descriptions of these materials and a description of how the materials are to be placed or are expected to perform after being placed. There are factual specifications to be verified by tests and there are other specifications that are procedural. Procedures cannot be verified by laboratory testing, but can be verified by observation. The number of passes a roller makes is procedural. However, the weight of the roller and the diameter of the rolls are factual.

MATERIALS CONTROL is one tool the project engineer uses to insure compliance with the specifications. ADEQUATE MATERIALS CONTROL is the proper use of this tool. Qualitative testing is performed on some materials before they enter the work, and on others after they have been placed. The hardness of the aggregate is tested before the rock is used. The density of the compacted aggregate layer, however, can be determined only after the rock has been processed by the contractor. Both kinds of specifications must be clearly spelled out in the special provisions.

The procedures required by the specifications, in many cases, should be tested and verified. For instance, does the number of passes required of the roller produce the necessary density. If the contractor uses newly developed equipment or processes, tests on the processed materials will furnish a basis for acceptance or rejection. Some specifications omit any reference to procedures, and the manner in which the work is performed is not considered critical. The work or material, therefore, must be evaluated by end product testing. When the material or the state of material fails to meet the requirements, removal and replacement of the substandard material are necessary.

The ultimate in this end result contracting has been used in Europe. The contractor bids on the design, construction, and maintenance of a roadway over a prescribed route. General criteria for geometric and grade design are specified. The maintenance period may be for ten or fifteen years and, in a sense, this serves as the test of the quality of construction. European public agencies have found some success with this manner of construction. Contractors, however, have found that they must institute an adequate materials control program. The specifications as written by these European contractors are even more restrictive than those formerly used by the public agencies.

As you can see from the materials testing point of view, the specifications are extremely important documents. Formulation and enforcement of these regulations require the delegation and acceptance of many responsibilities.

RESPONSIBILITIES (DESIGN)

The designer's responsibility is to understand the significance of the specifications and to know what is expected of the materials and, particularly, to exclude those specifications nor enforceable.

PROJECT ENGINEER

The project engineer is responsible for enforcing the specifications. The popular concept that the specifications are only a guide is not only a miscarriage of intent, but it is an abortion. It is the duty of the project engineer to enforce all specifications. Any requirement that does not apply should either be excluded or amended.

MATERIALS LABORATORY

For the purpose of this discussion I shall refer to those responsible for the physical performance of tests as the materials laboratory. In actual practice, those men conducting control tests at the project should be under the direction of the project engineer. Without this chain of command much of the effectiveness of materials control is lost.

Advances made by the construction industry to perform greater volumes of work indicate the need for qualified personnel, properly equipped, who understand the importance of an effective testing program. Many of the qualitative tests may be performed by another division of the public agency, or at times these tests may be performed by commercial testing firms. In any event, tests performed away from the work site can present hazard to the adequacy of the materials control program. Without the cooperation of the materials laboratory, the project engineer has lost his most important quality control tool. The responsibility of the materials laboratory is to determine the facts and report them quickly and accurately to the project engineer.

CONTRACTOR

The contractor's responsibility is to understand the specifications before he submits a bid and to protest any poorly or unfairly written requirement before the bidding and not after award of the contract. It is the contractor's responsibility to investigate the materials he will be working with and to understand how they will compare with the requirements of the specifications. This may require the establishment by the contractor of an adequate preliminary materials evaluation program.

DEPARTMENT HEAD

The largest share of responsibility must be assumed by those in the highest positions in the various public agencies involved. The adequacy of any materials control program will be a direct reflection of the views of the top echelon of any highway engineering organization. Whatever his title—city engineer, public works director, road commissioner—the top man must recognize the necessity for control of materials. He must arrange for sufficient allotments of money and manpower to implement a control program. Finally, he must insist on compliance with the standards established by his program.

Highway engineers and materials engineers are being challenged to keep pace with progress. They must provide adequate materials control programs to insure construction of high quality, economical roadways. Highway engineers and materials engineers must meet this challenge with ingenuity and resourcefulness.

ADEQUATE CONSTRUCTION CONTROL
Acceptable Deviation

H. L. Day

In preparing this paper on acceptable deviation as related to adequate construction control, I have undertaken to examine deviations from plans or specifications in pavement construction materials from the standpoint of thickness or depth, percent compaction, and sieve analysis and sand equivalent. The data presented were taken from construction records for 1960 and 1961, or since the beginning of the record sampling procedures instituted in June of 1960.

Prior to the inception of the engineering audit of construction practices, the Idaho Department of Highways made little effort to check the depth of base and surfacing materials placed on the roadbed. Grade stakes or "blue tops" were placed at 100-foot intervals along centerline for subgrade and for each base course on interstate, primary, and state secondary highway construction. It was assumed that if grade were maintained at these stakes the required thickness of base would be obtained. On county secondary road construction, grade stakes were placed as far apart as 200 feet, or not used at all, depending upon the amount of engineering money available. In these cases the "pull" method of aggregate spreading was relied upon to obtain the required depth. The only occasions which warranted a post-construction audit were those which involved roadway failure which occurred prematurely in the life of the road. In these instances it was our practice to make a rather thorough condition survey to measure both the quantity and quality of the material in place. Since we have been made critically aware of the need to document construction activities, our methods of obtaining and checking the required depth have changed to meet the need.

On construction of interstate, primary, and state secondary highways, it is now the practice to blue-top the subgrade and each course of base at 50-foot intervals. In some instances, as the need arises, this distance is shortened to 25 feet. On federal aid secondary projects, however, we are still faced with the problem of not having enough engineering construction funds to apply the same standards. Therefore in these cases we still use the "pull" method of aggregate distribution supplemented whenever possible by placing grade stakes at intervals of 200 feet.

The "pull" method of aggregate placement depends upon the estimate of the unit weight of aggregate for its accuracy. We put our faith in the validity of laboratory test data for unit weight which is based on a 2-1/2 pound preliminary sample prepared to our conception of the aggregate the contractor will manufacture. To date we have been fortunate in that errors which could be attributed to incorrect unit weights appear to be slightly in favor of over-depth.

In August of 1960, we adopted a schedule of depth tolerances or deviations which were to be applied to record sample measurements. This schedule has concurrence from the division office of the B.P.R. The values listed in the following table represent the consensus among staff engineers as to what constitutes reasonable deviation, taking into consideration errors inherent in staking the pavement section and in the contractor's operations in placing materials.

Table 1.
Allowable Deviations in Depth

Material	Average deviation		Maximum deviation - individual test	
	in.	ft	in.	ft
Portland cement concrete	1/4	0.02	1/2	0.04
Plant mix	1/4	0.02	1/2	0.04
Road mix	3/8	0.03	3/4	0.06
Treated base	1/2	0.04	3/4	0.06
Untreated base (Total of all courses)	1	0.08	2	0.17
Select base	1-1/4	0.10	2-1/2	0.20

We have attempted to analyze depth measurement data from several projects which are representative of construction through the state and have presented these data in the form of normal distribution curves. The curves are shown in Figures 1 through 4 for measurements made in 1960 and 1961 for depths of untreated base and depths of plantmix surface. The number of tests available for 1960 are considerably fewer than for 1961. It appears, however, that the control in 1961 was somewhat tighter than in 1960. As you might expect, we achieved greater uniformity in controlling the depth of plantmixed bituminous surfacing than we did with untreated aggregate bases. A definite skew to the right or to the over-depth side is evident in all of the normal distribution curves. This is gratifying to a certain extent, but too wide a spread on the plus side is as indicative of poor practice as similar deviation on the minus side.

We have plotted on the normal distribution curves the allowable average and individual test deviations. These limiting values are indicated on the minus or under-depth side only since a lack of thickness was our principal concern in making up the schedule. The data indicate that the majority of the tests were well within the average tolerance, and that almost all of the samples were within the individual allowance. There are the inevitable few, however, which fall below the rather generous allowance for the individual measurement.

It is our practice to investigate such deviations beyond the allowable limits as soon as the first measurement is taken. Central laboratory personnel who take these measurements check the depth one station ahead and one station back of the area which appears to be shallow. If these supplemental measurements prove to be adequate, we consider that the deficiency is local and not serious. Should the additional measurements confirm the under-depth, the matter is referred immediately to district construction personnel who are expected to take remedial action.

As a matter of routine, the width of the roadway section is checked whenever there appears to be a serious deviation in thickness either above or below the specified requirement.

When our record sample teams obtain depth measurements in base courses, they also obtain samples for sieve analysis and sand equivalent tests. At the beginning of the program we attempted to take large representative samples of the material in place so that the gradations and sand equivalents could be marked as "acceptable" or "rejected" under the same standards as the control samples. We soon discovered, however, that spreading, mixing, and compacting the material on the road caused degradation of the aggregate, resulting in an increase of from 2 to 4 percent in the sand equivalent. Therefore, with the concurrence of the division office of the Bureau of Public Roads, we decided to run sieve analysis and sand equivalent on in-place samples for information only.

Early in 1961, the B.P.R. published an amendment to its record sample instruction memorandum which amplified the provisions of the latter. Under the terms of this supplemental publication we were permitted to establish record sampling at the point of aggregate production, if this was the point at which the material was accepted for payment. Since this is the case in Idaho, we have now shifted a portion of the record sampling work load to district personnel who are not directly responsible for project control. These people obtain record samples of aggregates at the crushing plants, run determinations of earthwork density, and inspect plant facilities for concrete, aggregates, and plant mix. Headquarters personnel are then left with the job of obtaining depth checks and samples of material in place. In making official acceptance of or rejection of tests for sand equivalent, gradation, and density, we are applying a set of testing tolerances or deviations which were developed in the central laboratory on the basis of the repeatability of the individual tests. These tolerances are shown in Table 2.

Table 2.
Testing Tolerances

Gradation	Percent allowed outside of specification limits
Sieve:	
3 in. through 1 in.	3
3/4 in. through No. 4	2
No. 10 through No. 200	1
Sand equivalent	Minus percent
Material:	
Concrete aggregate	4
Base and surfacing	2
Earthwork compaction	Minus percent
AASHO T-99	2
Vibrator standard	4

If the test results for a record sample fall outside of these tolerances we are expected to explain the deviation in the record certification letter which is prepared at the completion of each project.

In attempting to document these failures, two courses of action are usually open to us: First, if the project has not been completed at the time the failure is noted, and we have an opportunity to do so, we resample the material in place in the area adjacent to the one which is represented by the offending material.

Lacking this opportunity, we must take recourse to the field tests which have been run daily during the production of the material in question. Usually a close examination of the inspector's records will indicate whether or not the failing tests represent the material produced or whether it is an exception.

In the case of aggregate gradation failures, we have devised a method whereby all the test data are presented in graphical form for quick review. We believe that this method is superior to one which involves a detailed examination of data presented in tabular form. The example which appears in Figure 5 shows a plot of test data for 3/4-inch maximum crushed aggregate base for the 3/4-inch, No. 4, No. 10, and No. 200 sieves. This example has been set up to illustrate an instance where we are obliged to document a failing in-place record sample. The sample was taken on August 17, and shows a deviation from specifications on the No. 10 and No. 4 sieves. The chart shows a plot of all the field tests run from 8-16 through 8-19. It also indicates the control samples and the production record samples which were taken during this same period. All the data tend to indicate that the in-place record sample gradation was not representative of the material produced, a fact which may be attributed to degradation or segregation.

This form of documentation has received the approbation of our field engineers to the extent that we are in the process of modifying the standard report form for field control of aggregate production. This new report form, instead of showing sieve analysis results in tabular form, will provide the chart necessary for recording the data in a manner similar to that shown in Figure 5. The inspector and the resident engineer will then have a running record of the material as it is produced, and there will be no need for recapitulation at the end of the project.

It is possible, of course, to record the sand equivalent data on the same chart that is used for aggregates. It is also possible to make a similar approach to the problem of documented record density test results. All of these forms of recording test data are an elemental approach to a statistical analysis of test results. In my opinion, we place too much emphasis upon the individual test in approving or condemning a piece of work. The occasional failure is not an anomaly when considered in proper relation to all of the test results. On the contrary, it should be expected and taken into consideration. It is my fond hope that in the near future we will be able to adopt quality control specifications which will enable us to make a rational approach to the problems of materials control to the extent that we will strive for uniformity within the specifications and accept the occasional deviation as part and parcel of any normal construction operation.

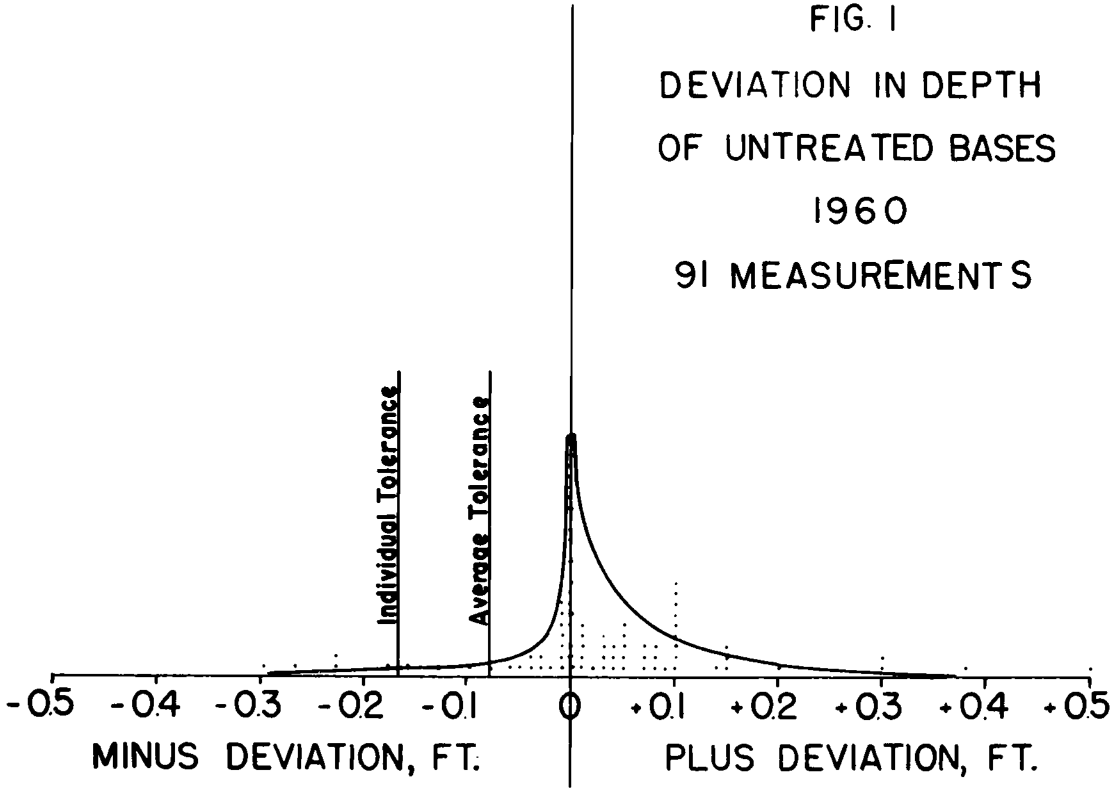


FIG. 1

DEVIATION IN DEPTH OF UNTREATED BASES 1960

91 MEASUREMENTS

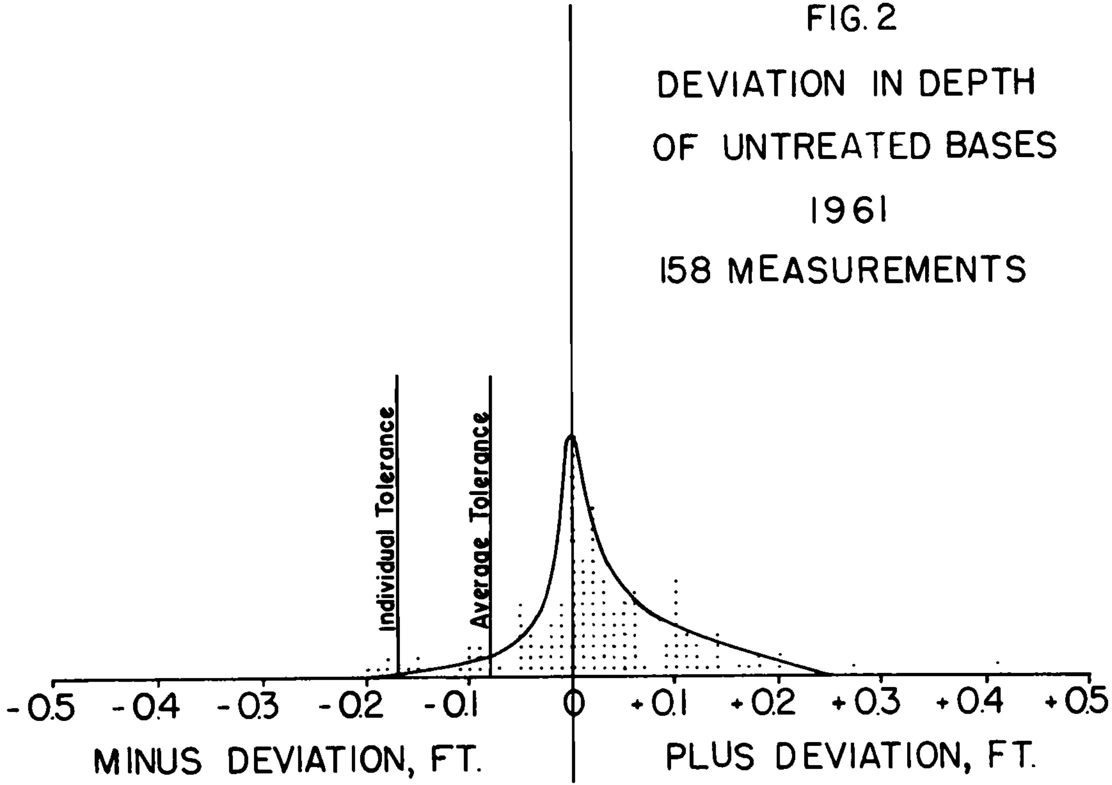


FIG. 2

DEVIATION IN DEPTH OF UNTREATED BASES

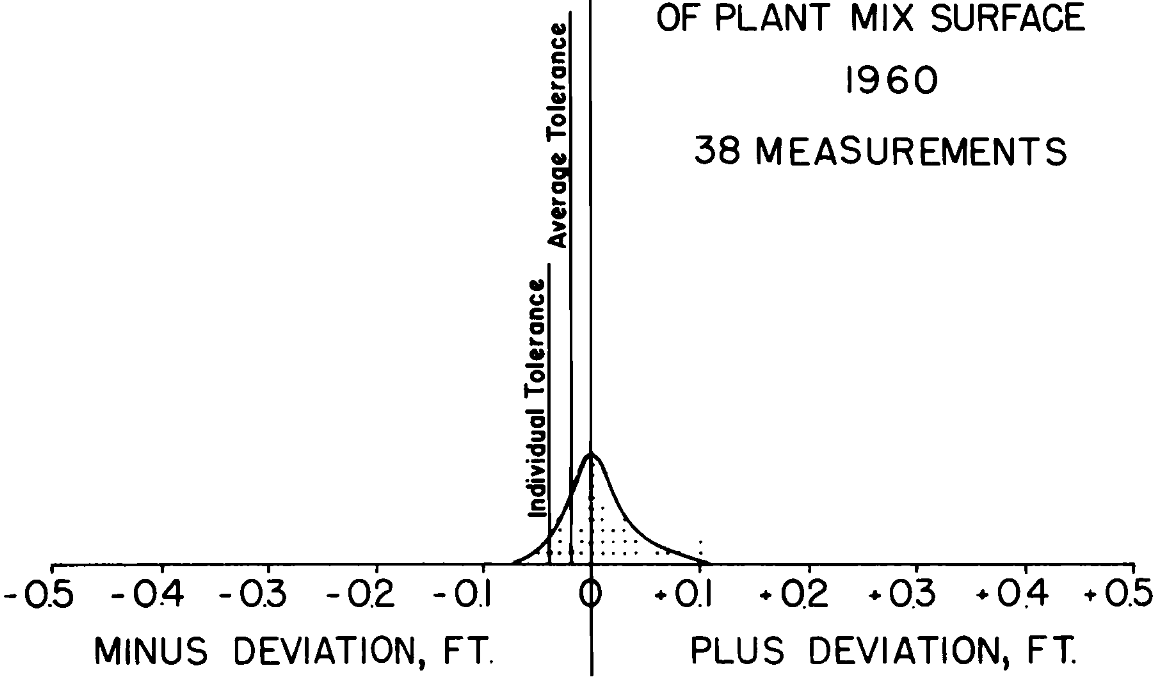
1961

158 MEASUREMENTS

FIG. 3

DEVIATION IN DEPTH OF PLANT MIX SURFACE 1960

38 MEASUREMENTS



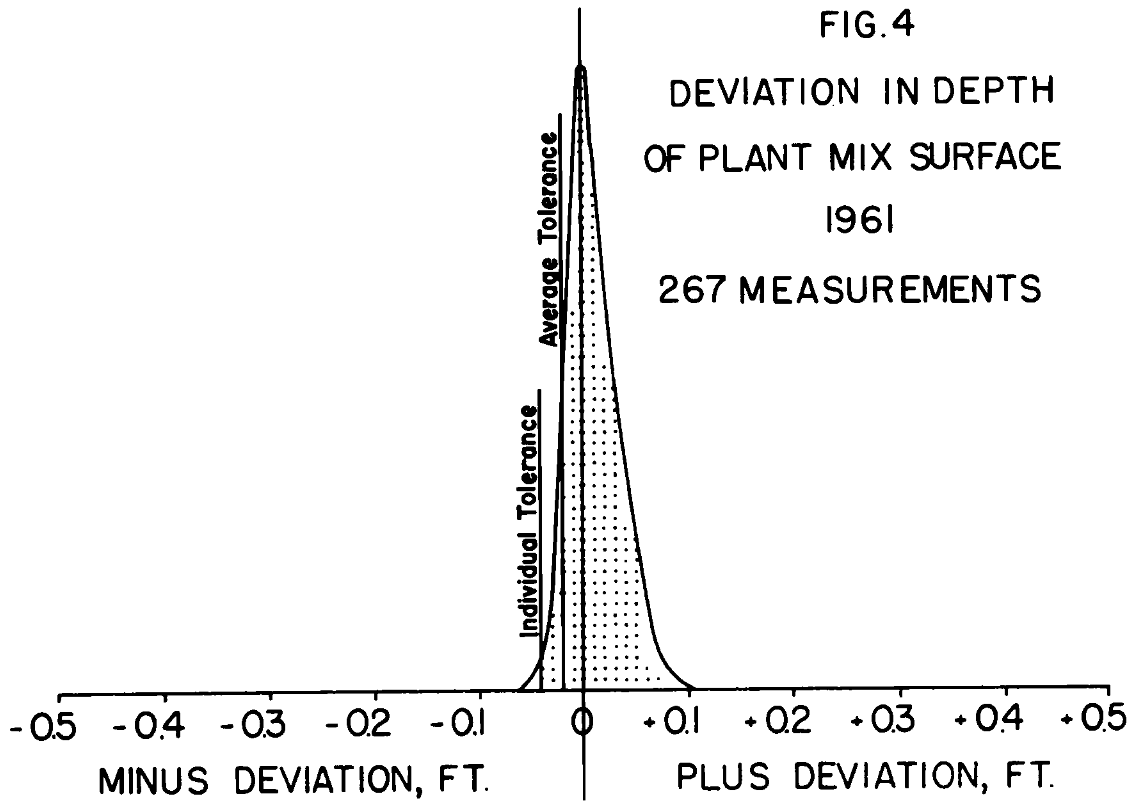


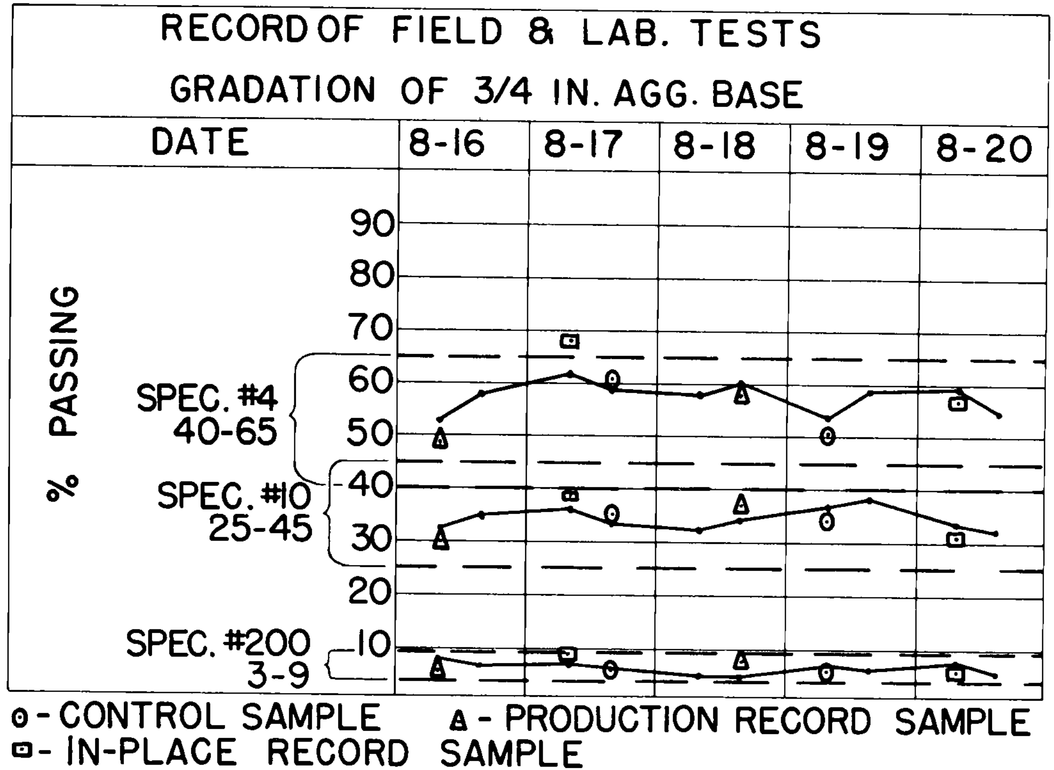
FIG. 4

DEVIATION IN DEPTH OF PLANT MIX SURFACE

1961

267 MEASUREMENTS

FIG. 5


RECORD OF FIELD & LAB. TESTS
GRADATION OF 3/4 IN. AGG. BASE
DATE
8-16
8-17
8-18
8-19
8-20
% PASSING
90
80
70
60
50
40
30
20
10
SPEC. #4
40-65
SPEC. #10
25-45
SPEC. #200
3-9
o - CONTROL SAMPLE
Δ - PRODUCTION RECORD SAMPLE
□ - IN-PLACE RECORD SAMPLE

ADEQUATE CONSTRUCTION CONTROL

Project Supervision:

Proper Specifications and Construction Inspection

Tom Edwards

There was a time when it was firmly believed by a number of field engineers that the proper place for job specifications was safely tucked away in a drawer—out of the way. A good mutual understanding between the engineer and the contractor as to what constituted a good job was the order of the day.

This has produced some good highways, and also has produced some failures. The fact that the average highway project today involves the use of more material for each mile of road built increases the likelihood of more frequent and even more spectacular failures. There is too much money involved in today's projects to allow such a procedure to continue in operation.

Today's project must have a background of thorough engineering investigation and testing, and a set of specifications to assure that the job is properly constructed. The specifications must be adequate, readable (and understandable) and, above all, realistic.

The purpose of the specification should be to insure that the finished product is the best and most usable facility consistent with practical economics. To insure this, these specifications must avoid ambiguity and be completely understandable by both contractor and project engineer. Anything else leads to confusion, extra costs, delays in job progress, and increased costs to both contractor and owner. This confusion leads to public criticism and all-around bad publicity, as well as claims for extra compensation by the contractor.

Specifications must be realistic. A specification which makes unreasonable demands in methods, materials, or end results, not only leads to increased costs, but tends to promote disregard for specifications in general. In its worst form, this leads to loss of job control and a situation which is entirely untenable.

Allowance must be made in the specifications for the conditions that will be encountered on the particular project in question. Where native material is known to be inferior, proper steps must be taken to insure that the specifications are written so that inferior material may be disposed of or utilized in a manner which is not detrimental to the finished product.

In order to enforce the specifications, contract supervision and inspection must be assigned to the project. It has been our experience that contractors want to do a good job, even if it comes to the hard choice of doing a poor job or losing money. Construction inspectors must be of the highest integrity and well trained. A delegation of authority to the project engineer and inspectors must be made and administered in a manner to instill confidence in themselves and to promote a general high level of good morale. Without this feeling of "pride of workmanship" there cannot be a satisfactory result.

A project engineer should be selected with care, as it is his responsibility to obtain the results envisioned by the plans and contract documents. He is the keystone of the project organization. All important instructions given the contractor by the project engineer should be given in writing or confirmed in writing, and become a part of the job file. He also should maintain a job diary listing all major actions, events, decisions, equipment operating, accomplishment, weather, and personnel assignments in a concise, accurate, and factual form.

It is a prime responsibility of the project engineer to insure that no material goes into the project that has not been determined by test or certification as satisfactory for use under the specifications.

The checking of material quantities delivered and incorporated into a project has always been a problem and will continue to be. However, some fundamental built-in safeguards should be observed. Materials which are paid for on a weight basis should be weighed only on tested or certified scales. Weighing of individual loads shall be done only in the presence of a state inspector, with the weigh ticket being signed by him. Validation of the materials receipt should require the action of two state inspectors; one at the point of loading and one at the point of delivery. Information furnished on the haul ticket should state the type of material, amount, identification of delivery vehicle, date, project, and point of deposit. Material receipts should be serially numbered, with strict accounting made for each receipt, whether used or unused. All material receipts validated by project personnel representing materials accepted and incorporated should be turned in at the end of each work day period to the project engineer and a reconciliation made at that time between quantities checked at the point of loading or weighing and quantities received on the road. When material is paid for on the volume basis in the transporting vehicle, the project checker shall record the size of the hauling vehicle by dimensions and take care that the proper volume is actually being delivered. Partially filled loads should be rejected or returned to the loading point to be completed.

It is extremely important that only personnel of the highest integrity be employed as materials checkers. The project engineer, during the course of the project, should, by personal observation, determine that the system used for the receiving of materials and receipting for them is not breaking down. He should constantly spot-check the performance of his materials inspectors.

Dimensional variations from specifications are not too difficult to control. Where thickness is a matter requiring control and measurement, such as in surfacing, it is well to pay for the item by weight or volume where possible. Thicknesses shown on the plans should be indicated as nominal, with an allowable tolerance indicated. The tolerance should be consistent with the economics involved, taking into account the requirements of design and capabilities of construction equipment, and consistent with obtaining a satisfactory finished product. However, even in those cases where the material is paid for by volume or weight, the inspecting force must be alert and endeavor to obtain the thickness named. When Portland cement concrete pavement is the pay item and is paid for by the square yard, tolerance limits are particularly important and quite narrow, and the specifications should take cognizance of the course of action to be followed if the thickness of pavement does not fall within the tolerance limits.

Modern paving techniques and equipment capacities on paving jobs have increased output to the extent that it puts a demand on the contracting agency to have sufficient personnel upon the job to make all necessary checks during the progress of the work. There is no effective substitute for skilled inspection and workmanship during the time that paving and finishing operations are under way. Any attempt to correct poor finishing to meet allowed tolerances generally produces substandard results.

Quality control can be obtained only by quality inspection in sufficient quantity. The old adage that an inspector should wear out the knees of his pants and not the seat, is still true. It is the surface of highways and bridges that the public sees and rides upon. Every effort should be made to finish these in such a manner as to present a pleasing appearance and riding quality.

There are some sound general guides which can be used in setting the project procedures for the earthwork segment of a project. Specifications covering density requirements should be realistic. Densities should never be specified that are impossible to achieve within the characteristics of the material and the weather conditions, or in excess of the requirements of design. Such requirements invite deviation from the specifications and make it impossible for the inspector to do his job effectively. It is suggested that ease of operation can be achieved by calling earthwork bids on a single classification basis. This can be modified by calling for bids between definite station limits where clear-cut changes in classification occur.

It is obvious, of course, that clear delineation should be made among the various types of excavation entering into the work—such as embankment foundation excavation, trench excavation, structural excavation, and drainage excavation. Specifically noting the types of excavation on the plans will serve to eliminate questions of type of classification at the completion of the work. Effective checks and double-checks on methods for estimating the grading quantities should include the following:

1. Initiate procedures for comparison of constructed quantities against preliminary.

2. Have sufficient soil characteristics tests made prior to construction to develop realistic shrinkage or swell factors. By so doing, it will insure that the balance of the finished job will be similar to the job contemplated at the time of contracting.

3. Require a written explanation from the project engineer for significant variances in the final estimate quantities from the planned quantities.

4. Require earthwork computations at the project level, at the district level, and spot-check at headquarters level before payment of final estimate.

In view of today's high-speed construction of earthwork, it is necessary that density checks of embankments be taken regularly and their results made known expeditiously in order to insure that specified density is being obtained. They should be made in such a manner so as not to delay the contractor's work. Field tests should be conducted by personnel properly trained. There should be provision made for spot-checks at intervals by inspectors from district or headquarters level. In order to not hold up the contractor's operation, the formal testing program must be supplemented by continued use of visual examination and possible proof-rolling. The inspector on an earthwork project must carefully control the depth of the lifts in which material is placed, the moisture content, and the application of the compactive effort.

The inspector on earthwork should keep a diary of the day's activities and a full record of his density checks and the results.

Since embankment failures are a major highway disaster, it is essential that the design should contain a factor of safety, and quality inspection be practiced to insure that the design strengths of materials are achieved.

Installation of adequate sub-drainage systems will become increasingly important if we are forced to marginal or somewhat unstable areas for highway locations. There are many solutions to embankment foundation problems. They are subject to change from that shown on the plans as the work progresses and the need becomes evident from the conditions encountered. After the treatment has been decided upon by the project engineer, an inspector must be present during placement of the material to ascertain the amounts used and that the installation is correctly positioned. He shall also record in his notes the true final location of any sub-drainage system. It is further recommended that the project engineer require that adequate photographs be taken as the work progresses, since the work is not visible after it is completed.

Construction of satisfactory flexible surfacings requires that control should start at the bottom. After it has been determined that a satisfactory subgrade, true to line, grade, and width is available, the construction of surfacing may be started in specified lifts. If the subgrade is irregular, either in grade or cross sections, the same characteristics will, to some degree, be transferred to the finished pavement. During the placement of the base materials to the specified layer thickness, checks must be made to see that proper compactive effort is being applied.

Appropriate density tests should be required to be taken by competent project personnel. Any deficiency in density in the base course should be detected during this operation and the condition corrected. Special care must be exercised to adequately and accurately finish the base surface immediately below the bituminous concrete. One of the fallacies of asphaltic concrete pavement construction is the belief that the paving machine, in its present state of development, will take out the humps and hollows. This is not true, and it should be pointed out that procedures based on this assumption will result in pavement thicknesses outside of tolerance limits. It cannot be stressed too strongly that the riding characteristics of the pavement will truly reflect the shape of the binder course prior to placing of the pavement. Inspection necessary to oversee the construction of surfacing operations should be of the very highest type.

Construction practices with respect to structures are somewhat more clear-cut than those of converting native raw materials into a roadbed and surfacing for highway travel. Here, again, however, there should be no laxity in inspection. Project procedures should be such that bearing power of foundations be determined with certainty. You are well aware that there is no second-guessing at this stage of the work. Sufficient inspection must be provided to the end that steel is properly placed after being tested to meet the strength and various other specifications by which it is controlled. Forms for concrete should be good, smooth, and strong to the point necessary to insure neat, clean-cut,finished surfaces. Aggregates should be properly tested, screened, and sized to permit full control of the mix. Cement should be tested and used in sufficient quantity to the end that dry or harsh mixes need not be used to secure adequate strength.

All of you are quite familiar, no doubt, with the details of the record sampling program which has been initiated. This is the "moment of truth." Record sampling should be done by specialized crews who should be thoroughly intent on determining the actual characteristics of the final product. If good project procedures have been followed, no deficiencies will be found. If any do occur, then an immediate examination of construction practices should follow, and the necessary steps taken to bring troublesome items under control.

In conclusion, I wish to remind you that construction people, whether employed by the contractor or by the engineering forces, have built up a reputation over the past years as being honest, conscientious, dedicated individuals. Any system of checks or balances should be designed to preserve this integrity. Serious thought should be given prior to making changes in procedures which have proved prudent through many years. Care should be taken to avoid multiplicity of forms, unfortunate or ambiguous language in specifications, nonuniformity of practices, and lack of faith in construction personnel to the end that resentments, ill will, and indolence will not occur.

ADEQUATE CONSTRUCTION CONTROL
Contractor's Viewpoint

Leonard A. Runkle

As the firm with which I am associated is primarily engaged in heavy and highway construction, I will direct my remarks to that particular type of construction.

In the past it has been considered the prerogative and the responsibility of the architect or the owner to maintain the proper quality control of the project. I believe, however, that at long last our industry is coming of age and the contractor is, or should be, assuming the rightful role of not only completing the project in the shortest possible time, but also of delivering a finished product that is the best possible to produce.

The importance of proper control of the project, not only in quality but schedule, is becoming paramount. Due to the ever increasing cost of operation, it is not only desirable but absolutely essential to exercise the best control of the job that is possible.

The complexity and high cost of our equipment makes it mandatory that it be utilized in the manner which the manufacturer intended. We can no longer fail to keep our haul roads in the best possible condition nor neglect the condition of the pit. When our equipment cost is in excess of $50,000 per unit, and is designed to travel 30 to 40 miles an hour, we cannot limit its capacity by failing to provide proper conditions under which to operate.

Getting back to quality control of the projects that we contract to perform for the state, government, or any other agency, or an individual for that matter who may not be in as good a position to adequately inspect the job as an agency that has proper facilities to handle that aspect of the work, we should, as responsible contractors, police our own work to assure a completed job in every respect that will give the public or private owner true value for each dollar expended.

The contractor must plan his job in a manner that not only maintains a schedule, but also produces a quality product that will stand the test of time and service. The old method of construction practice that was employed a few years ago was good enough for the load factor of that time, but it is not good enough for this age. Eighty-five percent density of the embankment and 6 inches of pit-run base rock may have been adequate in the Model T days, but Model T's are not on our highways now. As our highways are being subjected to heavier and heavier traffic loads, both in weight and speed, it is absolutely essential that our roads and structures be designed and built to higher standards than ever before. Today's highway construction standards demand better subgrade construction, with a well graded base and leveling course and a well designed surface to withstand the loads.

As Harold McKeever has said in one of our trade publications, "There is no mysterious formula for getting roads built properly, just common sense and down to earth practices. It requires a chain of command and proper communication from the top management to the very last man on the job to gain the objective that we should be striving for."

The technological know-how is available to build the best highway system of all time, but if it is not used, through neglect or indifference by the industry, we all are the losers.

With the congressional investigating committee turning up some shady construction in some parts of our nation, (I would like to state here that I believe this has been over emphasized and blown up out of all reasonable proportions) it behooves all of us, contractors and highway agencies alike, to take special care to assure the closest adherence to the specifications as is possible.

There are a few suggestions to the several agencies for whom we contract to do construction regarding some items that are of real concern to us as contractors. The subject of specification uniformity is an item that has been discussed many times and some progress has been made along this line, but much could be accomplished in this field if, in a spirit of cooperation, we would put forth enough effort to really go into the subject.

Another item that would make for better control of our projects would be the expediting of change orders by the agency that lets the work. While I believe in handling matters in a business-like way, through channels, it would greatly aid the contractor to get prompt action on any changes or modifications of the contract. Also, it is desirable, and I believe essential, to have as much authority vested in the resident engineer as is possible under the present regulations. This, of course, applies to the contractor's representative as well.

A real help to us as contractors, and to the industry as a whole, is the newly developed method of testing density of materials. It has materially speeded up the operation on embankment and surfacing construction on the project. I realize that many new techniques are being used in the testing of materials of all kinds but, as I previously stated, I will endeavor to keep my remarks in the field of excavating and surfacing.

One of the most important aspects of construction control is the proper traffic pattern through the project while it is under construction. Adequate detours should be designed by the owners and constructed and maintained in a manner that will allow the public to travel through the project with the very minimum of inconvenience because, after all, the public is the consumer in this case and should be given every consideration that is possible.

ADEQUATE CONSTRUCTION CONTROL
Records

E. C. Simpson

Webster defines the word "record" as ". . . to commit to writing, to printing, to inscription or the like; to make an official note of, to write, transcribe or enter in a book or on parchment for the purpose of preserving authentic evidence of."

When Mr. Webster wrote this definition it is doubtful that he had in mind the voluminous quantity of records and documents required to preserve authentic evidence of a highway contruction contract. There is no question, however, that his definition adequately covers the field of contract records.

In order to preserve authentic evidence of satisfactory completion of a highway construction contract, it is necessary that the following records be kept:

1. A history of the events occurring during the life of the contract, including the diaries and photographic records.

2. Adequate documentation of any changes in the contract plans or provisions.

3. A record of tests made to insure that materials incorporated in the work meet all requirements of the specifications.

4. A record of the quantities of materials incorporated in the work, including weigh slips, delivery records, etc. These records must also authenticate the method of measurement of the various quantities.

5. A record must be made of "as-built" dimensions of the completed project, including such features as pavement and surfacing depths and measurement of the dimensions of the roadway and structures.

All the records and documents listed above serve to support the measurements and computations of all quantities involved on a project for which payment is made, and to indicate that all materials entering into the construction meet the requirements of the specifications. All records should be complete and detailed enough to allow subsequent auditing and checking by competent personnel for the purpose of determining that the project was built in accordance with the specifications, and that the contractor was paid properly for the work performed.

With respect to specific records, I would like to emphasize here the importance and value of a complete diary. The resident engineer's diary, together with the photographic record and other documents, records the history of the project. It is important therefore that the diary be complete and detailed enough so that any authorized person may subsequently review the records and follow the course of events leading to the completion of the contract or of any particular item of the contract work. Each day's entry in the diary should record the weather conditions affecting the work, location and activities of major pieces of equipment involved in the work, a record of important conversations between the engineer and contractor, including any order issued to the contractor. It is important that the engineer show by name the person with whom these important conversations were held and to whom verbal orders were issued. In addition, the engineer must enter in his diary a record of any unusual conditions or occurrences affecting the course of the work.

Anyone who has had the experience of investigating contract records in connection with subsequent claims of a contractor will agree, we think, that a complete and concise diary is invaluable to the investigator.

A record must be made of all changes in the contract plans or provisions. Any major change from the contract documents should be approved in writing prior to beginning the work affected. Minor changes which are incidental and normal to the type of work involved will be documented in the final records for the project.

In the Washington Highway Department, we have discontinued the use of the old progress profile and have substituted therefor a system of revising the contract plans to show the project as built in the final records. We have found that considerable time and expense have been saved by the elimination of the progress profile from the final records.

The contract records must contain documents showing the results of tests performed upon the various materials incorporated in the work to verify that these materials met all requirements of the specifications. It is the responsibility of the resident engineer to see that the required number of control samples are submitted to the central laboratory for testing in order that the quality of the materials may be verified adequately in the records. We recommend a procedure whereby the central laboratory advises the resident engineer, prior to beginning of the work, of the number of control samples of each material required for testing.

When so-called end-product specifications are included to control the quality of the work, it is essential that the contract records contain evidence of adequate testing and satisfactory results. For example, when in-place density and moisture requirements are included for control of embankment compaction, the resident engineer's records must show that an adequate number of tests were made to insure that all portions of earthwork embankments met the requirements of the specifications.

In order to support adequately the quantities for which the contractor is paid, the contract records must be sufficient to verify that all quantities of materials and items of work for which the contractor was paid were actually incorporated in the work. When materials are paid for on the basis of weight, the records must show not only that the materials were weighed in the manner specified, but also must verify that all quantities were actually delivered to the project. Whenever possible, we try to avoid paying for materials on the basis of volume as delivered by truck due to the difficulty of verifying adequately the quantities actually placed on the roadway.

On federal aid projects, the Bureau of Public Roads currently requires a so-called final record inspection, at which time samples and measurements are taken of the completed roadway to verify that the roadway dimensions, pavement and surfacing depths and, to some degree, quality of materials incorporated in the work meet all requirements of plans and specifications. A record of the results of this inspection and sampling is included in the contract records.

In order that we may avoid situations where deficiencies are discovered after it is too late for corrective measures to be taken, we require that our resident engineers make appropriate measurements of such items as surfacing and pavement depths during the construction of each item. A record is made of these measurements and incorporated in the contract records. For example, measurements are taken of surfacing depths immediately prior to the placement of the pavement and records of these measurements are included in the inspector's notebook or diary.

The Washington State Department of Highways is currently following virtually all of the recommendations made by the American Association of State Highway Officials in their pamphlet entitled "An Informational Guide on Project Procedures," published November 26, 1960, as these recommendations are related to quantity and quality control procedures and records.

To summarize this discussion of the purpose and extent of records required for highway construction projects, I believe we can say that there are three basic reasons for keeping these records:

1. The records serve as a history of the construction work as well as a written record of engineering decisions and of changes in the original contract plans and specifications.

2. Contract records form the basis for the computation and determination of quantities of materials and work for which the contractor is paid.

3. They serve as a record verifying that the completed highway or structure was built in conformance with the plans and specifications applicable.

NEW MATERIALS AND METHODS

New Grades of Liquid Asphalt

L. R. Lovering

New grades of liquid asphalt were developed through a cooperative effort of both user and producer groups. At the Third Pacific Coast Conference on Asphalt Specifications held in San Francisco on October 12-13, 1959, a new set of liquid asphalt grades was developed to cover the entire range of engineering usage. These grades were accepted on a provisional basis for further study, and a proposal to modify the penetration limits on the MC residue from distillation was adopted.

Specification changes required for the new grades were then developed by the producers, based on agreements reached during the Third Conference, and on May 10-11, 1961, a Fourth Pacific Coast Conference on Asphalt Specifications was held in San Francisco. Those present included representatives of the state highway departments of Arizona, California, Idaho, Nevada, and Washington; Bureau of Public Roads; Corps of Engineers; and the County Engineers' Association of California from the users' group. The producers' group included representatives of 15 asphalt producers who manufacture or market in the western states.

At this conference, the user group, with the Bureau of Public Roads and Corps of Engineers abstaining, voted unanimously to adopt the following:

1. The proposed Modified Grades of Liquid Asphalt.
2. The kinematic method of measuring viscosity for these grades with the SSF method retained as an alternate. Temperature at which SSF determinations would be made to be 122°F, 140°F, and 180°F.
3. Viscosity limits as proposed at the Third Conference.
4. Adoption of the Modified Grades of Liquid Asphalt to be effective January 1, 1962.

A vote of the producers' group was then taken which indicated that the producers were in agreement with the action taken by the users.

Nomenclature to be used was then discussed and it was decided that the new grades would be designated by type, using the same letters as previous specifications, and by grade, using the lower limit of the viscosity range.

Minor differences of opinion regarding specification limits were resolved by a committee appointed by the chairman, and the specification limits were adopted.

The new grades as adopted are as follows:

SC-70	SC-250	SC-800	SC-3000
MC-70	MC-250	MC-800	MC-3000
RC-70	RC-250	RC-800	MC-3000

The only change which has been made by the new specifications is in the viscosities of the various grades. The new specifications include four grades of each type, with a definite or well defined gap between each of the successive grades. Also, the band of viscosity for each individual grade has been generally narrowed to produce greater uniformity between grades. A comparison of the new viscosity limits with the old limits is shown graphically on Chart 1.

As stated before, the grade designation is by the minimum kinematic viscosity at 140 degrees, and in each case the maximum viscosity is equal to twice the minimum. Limits chosen were selected to fit the desired construction uses of the liquid asphalts. An important feature is that the kinematic viscosity used makes it possible to represent all the grades on a continuous scale so that the relationship between the various grades is more readily apparent. The new specifications change in no way the difference among the three types of liquid asphalt.

As before, the SC grades represent a residual asphalt and contain asphalts, oils, and generally all of the various constituents up to the distillation points required to produce a particular grade. For this reason, these grades will harden much more slowly and will, a least for a considerable period of time, leave a softer residue in the mix than is the case with the other types.

The MC grades will, as before, consist of paving asphalt of about 120-150 penetration thinned with a cutter stock similar to kerosene. This type will set up more rapidly than the SC, and will leave a somewhat harder residue on the aggregate. This residue should, in a short time, approach the 120-150 asphalt which was used as the base stock.

The RC grades consist of 85-100 penetration asphalt, thinned with a more volatile cutter stock similar to naptha or gasoline. Because of the greater volatility of the cutter stock, the RC grades will usually harden more rapidly than either the SC or the MC to a product at least approaching the original base asphalt of 85-100 penetration.

Relative setting or curing rates of these various types of liquid asphalt will, to some extent, be influenced by the thickness of film used in the particular application and, of course, the prevailing climate in the area. For example, an RC cutback placed in a relatively thick film may not actually cure any more rapidly, or possibly not even as fast, as an MC because of a tendency to form a surface skin due to the rapid evaporation of the solvent close to the surface.

SELECTION OF GRADE FOR A PARTICULAR USE

In selecting a grade of asphalt for a particular construction use, it will be necessary as before to consider:

1. Base asphalt desired or required for the particular aggregate grading used.

2. Rate of curing to fit a particular construction need.

3. Consistency required to obtain a uniform mix with the equipment to be used or the depth of penetration desired if penetration treatment is used.

Since the rate of curing, and also the hardening of the asphalt after the cutter stock is evaporated, is affected by the climate of the area in which the material is used, and also because the mixing temperature which can be obtained will bear a distinct relationship to the climate, these factors must be considered in selecting a liquid asphalt for a specific purpose.

USES FOR THE VARIOUS GRADES

Grade 70. This grade is provided primarily for use as a prime coat, taking the place of Grade 1 of the old specifications. For this use, SC-70 would normally be used for fine graded or tightly bound bases, and MC-70, or possibly in extreme conditions, RC-70, would be used for fine graded but more open materials, such as relatively clean sands.

This grade may also be used for surface application for lightly traveled roads where a light wearing course may be obtained by penetration treatment. Use for this purpose would, again, be restricted to the finer materials in which a light liquid asphalt is required in order to obtain the penetration desired.

As for the prime coat, SC-70 normally should be used for materials high in passing the No. 200 and MC-70, or possibly RC-70 should be used for the more open soils which are relatively low in passing No. 200.

If the prime coat is to be followed by a chip seal, the use of SC should be avoided as the oily fractions contained in the SC grade may result in a softening of the sealcoat asphalt and result in loss of chips.

SC-70 or MC-70 also may be used as a fog seal or rejuvenation treatment for badly weathered pavements. In general, this use will be restricted to desert areas or regions where the climate is such that relatively rapid hardening of the asphalt may occur.

Grade 250. Grades 250 and 800 are the road mixing grades. Grade 250 should be used for road mixing with finely graded aggregates and soils at normal mixing temperatures. It also may be advisable to use grade 250 for the coarser aggregates if mixing temperatures are low. This grade will cover the uses previously assigned to grade 2.

SC-250 will provide sufficiently high cohesion for materials high in passing No. 200 sieve, and also will permit a somewhat longer mixing period than will be available with MC or RC-250.

RC-250 should be used for fine sands with less than approximately 10 percent passing the No. 200 sieve in order to obtain a sufficiently heavy base asphalt to provide the necessary cohesion.

MC-250 is suitable for fine soil intermediate between these two extremes.

The 250-grade may also be used for a prime coat or a penetration treatment in lieu of the 70 grade if the material to be treated is a relatively coarse, open-graded aggregate where depth of penetration is not a problem and the coarseness of the grading requires a heavier grade of asphalt to provide the necessary bond or cohesion.

Maintenance patching mix, which is to be stored in stockpiles for long periods of time before use, should be made with SC-250 to prevent or minimize caking or excessive hardening during storage.

Grade 800. Grade 800 is suitable for road mixing with graded aggregates during favorable mixing temperatures, covering the upper range of the old 3 grade and the lower range of the old 4 grade. Atmospheric temperatures above 70 degrees F, which would give a windrow mixing temperature of about 90 degrees F, would normally be considered satisfactory. The choice of MC, SC, or RC for this purpose will be influenced largely by the prevailing climatic conditions, as well as the actual grading of the aggregate. In the more northern climates where evaporation of the cutback solvents is less rapid, the MC, or even the RC grades will generally give best results. In the southern areas or desert regions, SC grade should be given first consideration. This grade also may be used for plant mix surfacing, which will have to be placed cold. It should not be used, however, for materials which will be held in stockpile for any length of time unless prevailing temperatures are quite high. If used for this purpose, the SC grade will set up less solidly in the stockpile and, for this reason, will be preferred to the MC grade.

Grade 3000. Grade 3000 is primarily the sealcoat grade. RC-3000 or MC-3000 is the better choice for this purpose. If the SC grade is used, it will be somewhat slow in setting and, except for very light traffic volumes, loss of chips may be expected.

The SC-3000 or MC-3000 may be used for plant mix surfacing for placing in colder weather or when a fairly long delay will occur between mixing and placing. It ordinarily will be necessary, however, to place this material before it has cooled and, if the delay is long enough for the mix to cool completely, one of the softer grades should be used.

The RC cutbacks are not recommended for plant mixing due to the fire hazard which results when the liquid asphalt is placed on the hot aggregates.

A summary of the new specifications is shown in Chart 2. If testing equipment is not available for measuring the kinematic viscosity, the following SSF viscosity limits may be used as an alternate:

Grade	70	250	800	3000
Kinematic viscosity at 140°F, cs	70-140	250-500	800-1600	3000-6000
Viscosity at 140°F, SSF	35- 70	125-250	400- 800	1500-3000
Viscosity at 122°F, SSF	60-120	-	-	-
Viscosity at 180°F, SSF	-	-	100- 200	300- 600

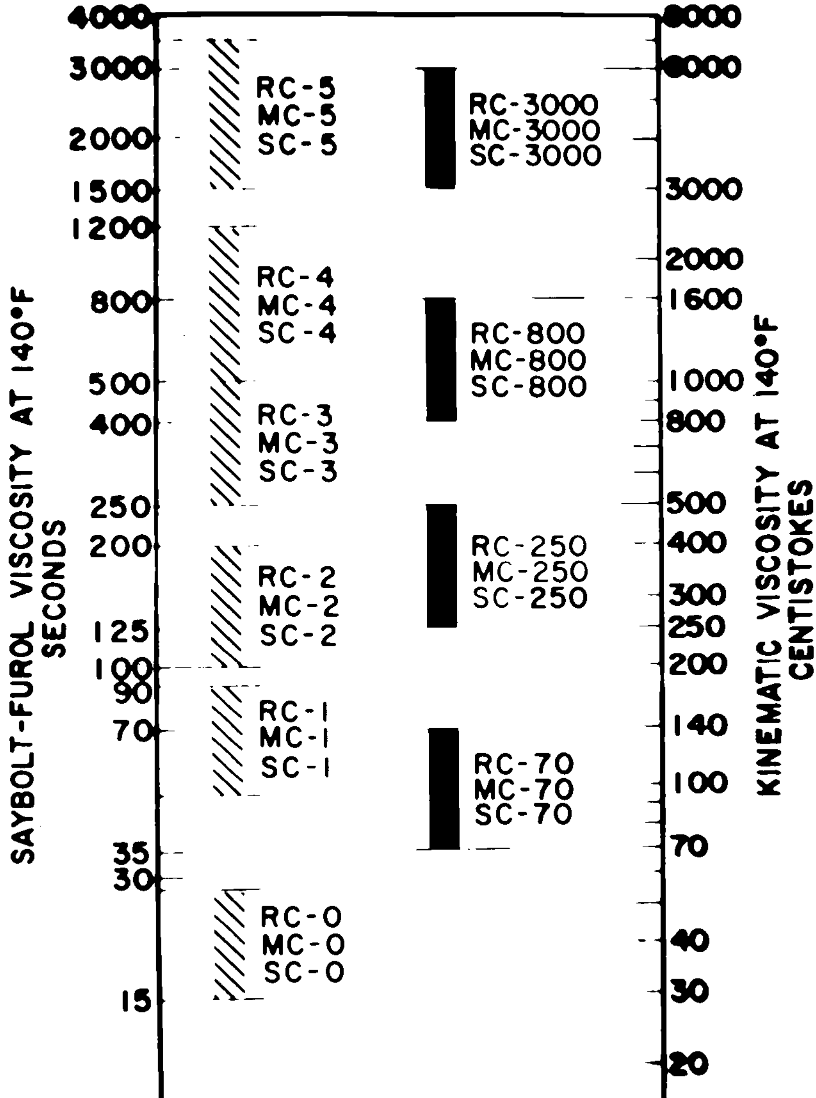

SAYBOLT-FUROL VISCOSITY AT 140°F
SECONDS
4000
3000
2000
1500
1200
800
500
400
250
200
125
100
90
70
35
30
15
RC-5
MC-5
SC-5
RC-4
MC-4
SC-4
RC-3
MC-3
SC-3
RC-2
MC-2
SC-2
RC-1
MC-1
SC-1
RC-0
MC-0
SC-0
RC-3000
MC-3000
SC-3000
RC-800
MC-800
SC-800
RC-250
MC-250
SC-250
RC-70
MC-70
SC-70
8000
6000
3000
2000
1600
1000
800
500
400
300
250
200
140
100
70
40
30
20
KINEMATIC VISCOSITY AT 140°F
CENTISTOKES

CHART I

Present Grades		0			1	2		3		4			5			
Adopted Grades				70			250		800			3000				
Viscosity at 140 °F - Kinematic, cs	20	40	60	100		200	400	600	1000	2000		4000	6000	10,000		

SLOW CURING LIQUID ASPHALTS

	AASHO	0	70	1	2	250	3	800	4	3000	5
Flash Point (C O C), °F	T 48	150•	150•	150•	175•	175•	200•	200•	225•	225•	250•
Water, %, Max	T 55	0.5	0.5	0.5	0.0	0.5	0.0	0.5	0.0	0.5	0.0
Distillation Total Distillate to 680 °F, %	T 78	15-40	10-30	10-30	5-25	4-20	2-15	2-12	0-10	0-5	0-5
Float Test on Residue at 122 °F, Sec	T 50	15-100	20-100	20-100	25-100	25-110	50-125	50-140	60-150	75-200	75-200
Asphalt Residue of 100 Penetration, %	T 56	40•	50•	50•	60•	60•	70•	70•	75•	80•	30•
Ductility Asphalt Residue at 77 °F, cm	T 51	100•	100•	100•	100•	100•	100•	100•	100•	100•	100•
Solubility in Carbon Tetrachloride, % (1)	T 45	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•
Heptane Xylene Equivalent, % (2 & 3)	T 102		35	The use of the spot test is optional		35-		35-		35-	

(1) Trichloroethylene may be substituted for Carbon Tetrachloride
(2) When specified by consumer
(3) Normal spot test and glass plate test repeated after 24 hours not required

MEDIUM CURING LIQUID ASPHALTS

	AASHO	0	70	1	2	250	3	800	4	3000	5
Flash Point (T O C), °F (4)	T 79	100•	100•	100•	150•	150•	150•	150•	150•	150•	150•
Water, %, Max	T 55		0.2	Material shall be free of water		0.2		0.2		0.2	
Distillation Distillate, % Total Distillate to 680 °F to 437 °F	T 78	0-25	0-20	0-20	0-10	0-10	0-5	–	–	–	–
to 500 °F		40-70	20-60	25-65	15-55	15-55	5-40	0-35	0-30	0-15	0-20
to 600 °F		75-93	65-90	70-90	60-87	60-87	55-85	45-80	40-80	15-75	20-75
Residue, vol % by Difference	T 78	50•	55•	60•	67•	67•	73•	75•	78•	80•	82•
Tests on Residue from Distillation Penetration, 77 °F, 100 gm, 5 sec	T 49	120-300	120-250	120-300	120-300	120-250	120-300	120-250	120-300	120-250	120-300
Ductility, 77 °F, cm (5)	T 51	100•	100•	100•	100•	100•	100•	100•	100•	100•	100•
Solubility in Carbon Tetrachloride, % (6)	T 45	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•
Heptane Xylene Equivalent, % (7 & 8)	T 102		35-	The use of the spot test is optional		35-		35		35	

(4) Flash Point by C O C may be used for product having Flash Point above 175 °F
(5) If pen of residue exceeds 200 and duct at 77 °F is less than 100 cm, material will be acceptable if duct at 65 °F is 100•
(6), (7), & (8) See (1), (2), & (3) above.

RAPID CURING LIQUID ASPHALTS

	AASHO	0	70	1	2	250	3	800	4	3000	5
Flash Point (T O C), °F	T 79	–	–	–	80•	80•	80•	80•	80•	80•	80•
Water, %, Max	T 55		0.2	Material shall be free of water.		0.2		0.2		0.2	
Distillation Distillate, % Total Distillate to 680 °F to 374 °F	T 78	15•	10•	10•	–	–	–	–	–	-	–
to 437 °F		55•	50•	50•	40•	35•	25•	15•	8•		–
to 500 °F		75•	70•	70•	65•	60•	55•	45•	40•	25•	25•
to 600 °F		90•	85•	88•	87•	80•	83•	75•	80•	70•	70•
Residue, vol % by Difference	T 78	50•	55•	60•	67•	65•	73•	75•	78•	80•	82•
Tests on Residue from Distillation Penetration, 77 °F, 100 gm, 5 sec	T 49	80-120	80-120	80-120	80-120	80-120	80-120	80-120	80-120	80-120	80-120
Ductility, 77 °F, cm	T 51	100•	100•	100•	100•	100•	100•	100•	100•	100•	100•
Solubility in Carbon Tetrachloride, % (9)	T 45	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•	99.5•
Heptane Xylene Equivalent, % (10 & 11)	T 102		35-	The use of the spot test is optional		35-		35-		35-	

(9), (10), & (11) See (1), (2), & (3) above

LIQUID ASPHALT SPECIFICATIONS

Fourth Pacific Coast Conference on Asphalt Specifications
San Francisco, May 10-11, 1961

New Pacific Coast Specs. (light box)

Present AASHO Specs (heavy box)

CHART 2

NEW MATERIALS AND METHODS

Slip-Form Paving

Gordon K. Ray

INTRODUCTION

In 1949, the first half-mile of slip-form paving was constructed in O'Brien County, Iowa. This was the first of some 800 miles of this new type of Portland cement concrete pavement constructed in Iowa and 14 other states up to the year 1961. Nationally, over 770 miles of this pavement have been constructed during the past 5 years.

EARLY DEVELOPMENT IN IOWA

In Iowa, postwar challenges of an immediate and urgent nature focused the attention of engineers on the necessity for developing and using new and more economical construction methods.

Marketing of agricultural products from the low population densities associated with high agricultural production in Iowa, demands an extensive highway system. The state ranks only 22nd in population and 25th in area among the 50 states, but it has the 6th largest road system in the nation, with a total of 111,670 miles. Over 90,000 miles are in the secondary system; the 34,000-mile, farm-to-market system is the largest of its kind in the nation.

Changes in requirements and in types and amount of traffic during the period following World War II resulted in an acute need for more high type roads. These roads were needed to reduce the cost of maintaining loose granular surfaces, to accommodate modern traffic safely and adequately, and to minimize the demand on diminishing aggregate sources. These same changes created the need for widening over 4000 miles of 18-foot width primary pavement to meet modern standards.

Concrete paving methods were reviewed to find more economical ways to satisfy these needs. In 1948, engineers advanced the idea that acceptable concrete could be placed with an extruding process in which forms would slip along on a well prepared subgrade. The forms moved away from the freshly placed concrete after it had been consolidated and struck off to the desired cross section.

An evaluation of the paving methods in use indicated that production costs could be reduced by eliminating the need for forming, with its attendant equipment and labor costs. Also, further reduction in costs could be effected by reducing the number of finishing machines and operations. An additional advantage would be gained in Iowa by the elimination of forming, because it would make paving operations on secondary roads more feasible. The average grade widths on most secondary roads are not adequate for the efficient operation of equipment necessary in the forming operations.

The Iowa Highway Commission engineers decided that the best way to meet the requirements of modern pavement construction was in the development of an extrusion method for paving. A small-scale working model was placed in operation on November 22, 1947. This model extruded a slab of consolidated and finished concrete 18 inches wide and 3 inches thick. The vibrating unit was actuated by a syntron hammer. The small motor on the rear of this machine drove a flat belt which produced the final finish on the slab. Forward motion was accomplished with winches.

The machine had a 7-1/2 degree batter on the side forms, which was retained on all experimental models in anticipation of some problems with edge slump. Later experience indicated that securing vertical edges on extruded concrete presented no serious problem.

The results obtained with the first working model were so promising that a larger machine was constructed. This second model, which extruded a slab 36 inches wide and 6 inches deep, was placed in operation on February 13, 1948. This model was basically similar to the first model. A small vibrator such as commonly used for internal vibration of concrete was used to actuate the vibration unit.

One feature of this second model was a considerable part of the force required to propel it was provided by the unbalanced reaction of the concrete against the machine.

The successful operation of this model proved that concrete pavement could be laid by an extrusion process, and that this method would result in a reduction of the total cost of concrete paving projects. This cost reduction would be effected by eliminating forming operations, by eliminating all but minor hand finishing, and by using a method which requires fewer pieces of equipment than those needed for conventional methods. In addition to these reductions in cost, the extrusion method of paving would be more satisfactory than conventional methods for paving secondary roads where narrow grades would not allow trucks to operate on the shoulders.

It is pertinent to note that the development of this working model resulted in the slip-form methods used for widening approximately 1600 miles of pavement in Iowa up to the year of 1961.

With the successful operation of this second model sufficient data were secured to warrant a full-scale field experiment. Accordingly, a final motorized working model was developed. This model extruded a slab 10 feet wide and 6 inches thick. Basically, this large model was quite similar to the two previous models except for a saddle-yoke type of power unit which pulled the basic paver along the grade. Pulling connections were two short pieces of chain attached to the front end of the paver. This arrangement allowed the paver to react independently of the power unit, and any settlement of the wheels was not reflected in the pavement thickness. The paver also could be suspended from the power unit for transportation.

In 1949, this pilot machine was used to construct a half mile of experimental pavement in O'Brien County. A second experimental project one mile in length was constructed later that year in Cerro Gordo County.

These two projects had adjacent 10-foot lanes. A 3- to 4-inch gap between the slabs was filled with asphaltic concrete. In spite of the unusual design required by the pilot machine, these two projects demonstrated conclusively the feasibility of the slip-form paving method, and acceptance of formless pavement by county and Iowa Highway Commission engineers was enthusiastic.

Though generally accepted, little progress was made in slip-form construction during the next five years. This can be attributed to the delay in development of a commercial paver. One Iowa engineer became impatient and secured permission to rent the pilot model for construction of a 2-mile project in 1954.

On this project, built in Greene County, a job trial was made at filling the 3- to 4-inch gap between the two lanes with

Portland cement concrete immediately following the construction of the second lane. The battered edge was still used, and there was some objection to abutting the two slabs with other than a vertical joint. Several years of life on this pavement have demonstrated that this feature was not too objectionable.

A commercial slip-form paver was finally available in 1955. This machine was designed on the same basic principles developed by the Iowa State Highway Commission, with two major exceptions. In this commercial model the concrete was deposited directly on the grade instead of in a metering hopper, and the model was mounted on crawler tracks. It was actually developed from a model made by a paving contractor.

Use of slip-form paving methods in Iowa increased rapidly when this machine became available. Approximately 28 miles of 6-inch pavement 20 to 22 feet wide were constructed in 1955. Approximately 550 miles of slip-form paving have been constructed in Iowa during the past six years. Some 30 percent of this total was constructed on the primary road system. On most of the secondary roads selected, the total average daily traffic was 155 vehicles per day with a maximum total ADT of 620, including a maximum truck ADT of 90.

With this in mind, the pavement was constructed on a subgrade shaped to conform with the existing road profile. This shaping was accomplished by motor blade graders without grade stakes or other controls. Pavement surface tolerances were 3/16 inch in 10 feet. Contraction joints were quite generally accomplished by sawing. Other methods were permitted, however. Several methods of curing were permitted, but white pigmented curing compound applied soon after the final finish was the method most generally used.

Again in line with the intent of the special provisions, a table of concrete proportions was designed on a strength and quality basis which allowed the use of highly sanded mixes. Since these proportions allowed greater use of local materials, further cost reductions were possible. These proportions also allowed contractors to select design mixes ranging from 1-1/4 to 1-1/2 barrels of cement per cubic yard. Quality requirements for all materials were the same as required for all other concrete.

Completion of these early projects demonstrated that quality concrete pavement could be placed 20 to 24 feet wide without using fixed forms, and that vertical instead of battered edge forms could be used. However, the early paver and construction methods had some objectionable features. It was demonstrated that some method should be provided for striking off the concrete before it started through the paver. The paver, as originally designed, had no preliminary method of striking off the concrete before it passed under the pan of the concrete laying machine. This was objectionable because the machine had a tendency to climb onto the deposited piles of concrete. This lifting effect caused the machine to lose its traction and form an undesirable surface.

The specifications were changed to require that the machine for placing the concrete should have some mechanical device for striking off the concrete to a uniform depth before it was fed under the pan of the paver. This was accomplished by adding a bulldozer arrangement on the front of the machine which was operated by hydraulic rams.

The paver now was mounted on a 22-foot track laying crawler on each side. In addition to the ram for strike off there was a vibrator, a tamping bar, and an extrusion plate which shaped the pavement to the desired cross section. The extrusion plate could be changed for parabolic or flat crowns with a quick change device included. This was followed by a mechanical belt.

All of these operations were enclosed between the two 16-foot side forms. These, in turn, were followed by two or three lengths of 16-foot trailing forms separated by trusses above the slab, the last one trailing a burlap drag for final finish. If necessary, any straight edging and edging could be done inside these trailing forms.

Although the pavements on these early projects had a satisfactory surface tolerance, as measured by Bureau of Public Roads type of roughometer, the undulations in the grade line made them uncomfortable for high-speed driving. To correct this, the specifications were changed to require that the wheels, tracks, or skids of the laying machine should operate on surfaces prepared by a form grading machine. Also, it was required that the subgrade between these tracks be completed not less than 500 feet in advance of the operation of placing concrete.

Carefully and accurately set string lines for alignment and grade now are required to be maintained ahead of the paver for a distance of not less than 300 feet. The specification requires a smooth subgrade that is true in grade to secure quality slip-form pavement. In addition, an adequate supply of concrete of uniform consistency must be kept in front of the paver at all times. Continuous forward movement of the paver gives the maximum surface smoothness.

The possibilities of securing an excellent riding surface with slip-form paving methods were indicated in the results of a straight edge survey of the one mile project constructed with the pilot model in 1949. A total of 2022 points were checked in both lanes with a 10-foot straight edge. Less than 12 percent of the total points measured showed a deviation of 1/8 inch, and only 3.6 percent showed a deviation of 1/4 inch.

Road roughness measurements on slip-form pavement as determined by a Bureau of Public Roads type of roughometer have consistently been less than those on conventional pavement. The weighted average road roughness for approximately 104 miles of pavement constructed by slip-form methods in 1960 was 64 inches per mile. This is 14 inches per mile less than that obtained on 193 miles of conventional pavement. Undulations in grade line on the earlier projects have been eliminated by improved construction procedures.

In summarizing Iowa's 14 years of experience in pioneering and developing slip-form paving methods, probably the best indication of whether a cost reduction can be effected by using slip-form methods would be an evaluation of the contracts which gave the contractor a choice of paving by the slip-form methods or by fixed forms methods. Less than 23 miles out of approximately 524 miles in Iowa were constructed by conventional methods. Most of these 23 miles were constructed by one contractor. He is now paving with slip-form methods. Five large paving contractors in Iowa now have slip-form paving equipment.

The range in price on the 1960 secondary projects through June 1961 was $2.40 to $2.98 per square yard, with an average price of $2.52 or $29,600 per mile for pavement 20 feet wide and 6 inches thick. This average price has varied from a low of $2.50 in 1959 to a high of $2.56 in 1958. The range in square yard price for 1961 was $2.54 to $2.84, except for one short project which was $3.18.

SLIP-FORM PAVER PROJECTS IN OTHER STATES

While this early developmental work was underway in Iowa, engineers and contractors from other states watched with interest. In 1955, a contractor in Illinois built his own machine and paved several miles of base pavement for the Illinois Division of Highways. Another Illinois contractor used an early developmental machine made by one manufacturer to pave his equipment yard near Chicago. When the production model became available, its use soon spread to other states. Texas contractors used it to pave shell-concrete base 12 inches thick. In Wyoming and Colorado the slip-form paver was put to work immediately on primary and interstate projects. In Colorado an experimental section was built incorporating distributed steel in the form of welded wire fabric to determine whether it could be used with slip-form paving.

Colorado was so pleased with its early projects that specifications on all concrete highways were revised to permit use of the slip-form paver. To date, approximately 258 miles have been built in Colorado, with over 200 miles of it on the Interstate System.

Minnesota and North Dakota built their first projects in 1958 and 1959, respectively, and North Carolina in 1959. This first project in North Carolina resulted in a second project in that state in 1961, followed immediately by one just across the line in Virginia. Both of these are on Interstate 95.

Meanwhile, slip-form pavers were used in Ohio for constructing integral curb residential street pavement, and in Rhode Island for paving 8- and 10-inch airport aprons. New Mexico's contractors have used the slip-form paver on interstate highways. In Nebraska the State Highway Department permitted its use on two primary highways in 1961. Also, in 1961, it was first used in Michigan on a county road in Oakland County.

SLIP-FORM DEVELOPMENTS IN CALIFORNIA

Almost as dramatic as the early slip-form developments in Iowa have been the modifications, new machines, and the use of slip-form pavers on multilane high-speed freeways in California.

Slip-form pavers were used to pave 8-lane divided highways with keyed (tongue and groove) longitudinal construction joints containing tiebars with 9-inch concrete in the outer two lanes and 8-inch concrete on the inner two lanes, all on a cement-treated subbase. New modifications included spud type vibrators instead of the original horizontal tube, substitution of a V-shaped longitudinal float for the original belt finish, and elimination of all or most of the trailing forms. Hand finishing was virtually eliminated.

At the same time, a California contractor with experience in the construction of slip-formed canal linings, built several projects using a modification of the canal paving machine. Although similar in principle to other slip-form pavers, this machine had several innovations, including a hopper type spreader and electronic controls for both vertical and horizontal alignment.

While some of these early projects could not meet the rigid California specifications for surface smoothness without considerable surface grinding, as measured by the profilograph, they did establish the practicality and economy of slip-form paving on urban freeways as well as rural county roads.

In 1961, modifications and greater care with the first two machines, development of a third paver by a California equipment manufacturer, and the innovation of a round pipe float pulled diagonally behind the paver resulted in pavement riding surfaces well within the tolerances established of 7 inches per mile in each wheel path. On one project a modified machine following three 34-E dual drum pavers placed three 12-foot lanes simultaneously, even cutting the two longitudinal joints as the machine moved forward.

SUMMARY

The slip-form paver has established itself as a suitable piece of paving equipment from coast to coast. Rural two-lane county roads, urban freeways, airports, parking lots, and integral curb city street pavements in housing developments have proved its versatility. Prices as low as $2.40 a square yard for 6-inch pavement had proved its economy. Contractors in 14 states, Canada, and Switzerland have proved its capabilities. It is now up to highway engineers in cities, counties, and other state highway departments to permit its use on their streets and

highways by the necessary revisions in construction specifications.

It is impossible to say that all concrete pavement in the future will be built with the slip-form paver, but there is no doubt that it represents definite progress in paving construction techniques. Its use brings the price of concrete pavements down to a point where they can be used for all classes of roads and streets if properly designed for the anticipated traffic and soil conditions.

NEW MATERIALS AND METHODS

Review of Field Methods to Determine Culvert Durability

Paul W. Sturmer

Since its inception, the corrugated metal pipe industry has recognized the need of protective coatings on metal pipe culverts. Galvanizing was the first generally accepted protective coating, and at the present time plain galvanized corrugated metal pipe is readily accepted as possessing a potential service life commensurate with required design standards. Fortunately, the far greater percentage of soils and waters in the northwest area of the United States is not excessively aggressive in the corrosion of metal culverts. There are exceptions to this generally favorable environment.

It is the purpose of this paper to review some of the work done in recent years in an effort to allow the engineer a method of identifying culvert locations which may prove excessively corrosive so that additional protective coatings may be designated for corrugated metal pipe to be installed at those locations.

The National Bureau of Standards has done an enormous amount of work in the field of corrosion. Much of this work was done in cooperation with utility companies concerned with long pipe transmission lines such as gas, water, and oil lines. In 1955, there were 988,000 miles of these metal lines in the United States. There is not much doubt that this figure now exceeds one million miles—certainly a tribute to steel in underground service.

As stated by National Bureau of Standards publications, corrosion studies include soil analyses for determining the chemical elements soluble in water. These are usually the base forming elements such as calcium, magnesium, sodium, and potassium, or the acid-forming elements such as sulphate, nitrate, chloride, or the carbonates. The moisture content of the soil, together with the soluble salts present, will determine the electrical resistivity of the soil. That is the ability of the soil to conduct an electric current. Wet soil possessing relatively large amounts of soluble salts will conduct an electric current rather readily, and this will show a low resistivity reading. Conversely, a dry soil having a relatively small amount of soluble salts, will not readily conduct an electrical current, and will show a high resistivity reading. By using a portable field resistivity meter, it may be determined in the field whether or not a given culvert location may present an environment relatively noncorrosive or possibly corrosive to corrugated metal pipe. This electrical resistance is measured in ohms per cubic centimeter. The field resistivity meter usually used for this work is equipped with a steel probe. This probe is inserted into the soil and the resistivity reading taken directly from the meter.

The next step in determining whether a given soil is relatively noncorrosive or corrosive is to determine the intensity of the acidity or alkalinity of the soil, which is expressed as the pH value. It is common knowledge that a pH value of 7 indicates neutrality, and that readings lower than 7 indicate acidity and the higher values alkalinity. Readings below 4.5 indicate extreme acidity, and readings of 9.1 or higher indicate a very strongly alkaline condition. Readings between 6.1 and 8.4 will indicate a range varying from slightly acid to moderately alkaline. pH readings are easily taken in the field, and are read directly from the portable meter designed for this purpose.

The physical properties of the soil also should be considered in corrosion studies. It is entirely probable that the conditions encountered at the original culvert site, insofar as resistivity and pH readings of the soil are concerned, may be completely changed upon completion of the culvert installation.

As an example of this, let us for instance assume an original culvert site is a poorly drained, swampy area in which the original soil is entirely unsuitable as a foundation material for any kind of drainage structure. During the process of construction,this unsuitable material, which may show a low resistivity reading, and by the pH reading indicate an acid condition, will be removed. It will be replaced with a granular material for the purpose of building a suitable foundation but, at the same time this is done, the soil removed, which may have been excessively corrosive to metal, has been replaced with material of an entirely different nature. All of the backfill for the culvert structure will also preferably be of a granular type so that during the standard procedure of good construction practice many of the factors that might contribute to corrosion have been removed.

Probably it would be good practice to take resistivity and pH readings of backfill material. Granular materials that are relatively free of silt and clay have low plasticity and do not readily hold appreciable amounts of water. They do not expand and contract when alternately wet and dry as do clays and silts. In addition to the advantages of a granular material in resisting applied loads, the relative permeability of granular material to moisture and air will usually result in its being noncorrosive.

In order to make clear the reason for taking resistivity readings of soil, and also to give a completely valid reason later for using some care in handling and installing corrugated metal pipe, an attempt to just touch on the theory of underground corrosion will be made.

Practically all of the corrosion of steel in underground service results from an electrochemical reaction which occurs when there is a potential difference between two points connected electrically and emersed in an electrolyte. In the case of a metal culvert, the two points would be two spots on the culvert which would be connected electrically by the pipe itself. The electrolyte would be the soil surrounding the culvert. With these conditions satisfied, a slight electrical current flows from the point on the pipe having the most negative potential, which would be the anode area through the electrolyte (in this case, the soil) to the cathode area, the other point on the pipe. On reaching the cathode, the circuit is completed by the current flowing back through the pipe to the anode area.

The anode area is the area at which the corrosion occurs because of the loss of metal ions to the electrolyte. The cathode area will not corrode because those ions which carry the current will be deposited in the cathode area. There are so many factors which may affect this electrochemical reaction that actual rate of corrosion is difficult to predict. Usually, the corrosion of metal culverts, which are relatively short as compared with water lines or gas lines, is of the slow, uniform type, and no doubt accounts for the thousands of installations which have served for 30 years or more and still show very little loss of metal.

With this theory of corrosion in mind, it seems apparent corrugated metal pipe also should be handled with some degree of care after arriving on the project. I believe we all have witnessed at one time or another a corrugated pipe dragged or roughly handled over an abrasive surface, or dumped rather than lowered into a trench. Corrugated pipe is tough, it is true, and although no immediate damage is apparent, the practice of rough handling does damage protective coatings and should not be tolerated.

Resistivity and pH reading will definitely give a good indication of the types of soil encountered and will indicate whether it is desirable to provide extra protection by specifying a bituminous coating or, in the case of the indication of extremely corrosive condition, indicate the need for using an asbestos bonded and bituminous coated corrugated metal pipe. There is no question concerning the tremendous value of inspecting existing culverts in the vicinity and incorporating this information in the total analyses of any given culvert site. By investigating the time in service, present condition, and probable total serviceable life of an existing culvert, the engineer, by taking resistivity and pH readings of the materials in contact with that culvert, is certainly in a far better position to design a new structure in that same area for a given service life.

The California State Highway Department has done extensive work in this field. During the past 35 years they have investigated and evaluated more than 12,000 corrugated metal culverts in the State of California. As a result of these studies, it is now felt their field and laboratory testing procedures allow them to estimate within approximately 12 years the actual serviceable life of a corrugated metal culvert. This affords their design departments a basis on which to select the type of culvert considered necessary to comply with the service life intended.

NEW MATERIALS AND METHODS
Wood Products

W. R. Bond

Back in 1930, Henry Ford foresaw the possibilities obtainable by using soybeans as the main source of raw materials for industry. From this he developed the soybean plastic used in gearshift-lever knobs, accelerator pedals, timing gears, horn buttons, and many other uses. Of particular importance today is the philosophy of his statement predicting greater use of growing plants as materials of construction. I quote

> When we use up our mineral resources we are living on capital; they are gone for good. Materials grown on the farms (and in the woods) are renewable, and the use of them creates wealth all around.

Remember this, "When we use up our mineral resources we are living on capital; they are gone for good."

A material now is being produced that is available in vast quantities. It is self renewable so it will always be available and, when properly used in design, is strongly competitive in cost. It will not shatter under impact loads. Its resilience permits it to absorb shocks which would crack or break other material. It has great insulating quality. It can be produced in large sizes when large sizes are needed. It can readily be manufactured into structural members or products, whether beams, strings, girders, arches, trusses, foundation piles, lighting poles, culverts, guardrail supports, or numerous other items common to the roads and streets engineer. It is permanent. It is relatively maintenance free. It can be used repeatedly. It responds to the simplest of tools. It is relatively light in weight but has great strength.

What is this remarkable new-sounding material? It is pressurized wood. Wood that has been preservatively pressure-treated. A good product much used and abused, but which now is better made. This superior renewable material fits extremely well into the subject under discussion—"New Materials and Methods."

Glued Laminated

One important development in the highway field is the use of pressure-treated, glued laminated structural members for long-span stringer bridges and pedestrian overpasses. In the past, the sawn stringer structures were limited to spans dependent upon the length of timbers available. Today, spans of 75 feet and longer are being built with this new material. It is an engineered product readily available at competitive cost.

Composite Construction

Another method of bridge deck and dock construction worthy of consideration for either contract or force account jobs is the composite laminated pressure-treated timber-concrete deck. The design commonly used is one published by WCLA, a modification of that patented and published originally by the AWPA. The section is made up of 2- or 3-inch pressure-treated wood laminations topped with approximately 4-1/2 inches of concrete to provide a wearing surface and accommodate compression stresses. Depth of the laminations is dependent upon design loading. Alternate laminations are elevated 2 inches, dapped and grooved to provide bond and develop sufficient shear strength. These laminations are shop fabricated and assembled in panels before shipping so that the difficult framing can be efficiently accomplished with power tools and savings can be made on installation labor costs.

This type of construction has been successfully used by several counties in California (San Benito and San Luis Obispo, for example), by Multnomah County on Swan Island, together with other Oregon counties, by the U.S. Forest Service, Department of Public Works in Canada, and, more recently, by Moffat Nichol and Taylor in designing the eastern approaches to the Hawthorne bridge in Portland.

While no great savings in cost may be discernible, as compared with monolithic or precast construction, I do believe that with proper development it could prove to be a more económic and efficient tool, particularly for those structures of short single or continuous spans where available funds restrict the dimensions to accommodate only immediate traffic needs, and where such structures will require widening in the future. This method lends itself quite readily to easy and economic expansion of roadway widths. Panelization of the laminated timber section provides a more speedy installation (much quicker than form work for cast-in-place decks). Generally, a complete deck can be assembled in one day ready for temperature reinforcing and pouring. Bridge widening can thus be completed in a matter of days and without interfering with traffic. The most economic substructure, of course, consists of pressure-treated timber piles.

Culvert Widening

Many counties are facing the necessity of widening hundreds of existing concrete culverts of various dimensions. Many of these present a real problem inasmuch as disturbing the existing structure by cutting into it could invite a complete replacement due to the unknown qualities of the cement aggregates and reinforcing used during its original construction, or that the headwalls could not take any additional superimposed dead load or live load. Two alternate methods can be used, depending upon equipment, time, and labor available.

Two or more pressure-treated wood pile bents may be driven, or pressure-treated framed bents may be erected, depending upon foundation conditions in the stream bed, and the extensions completed with pressurized timber bulkheads and decking in a manner similar to that in regular bridge widening.

Another method is that a laminated pressurized timber culvert of the same interior dimensions can be prefabricated and panelized to be set into the ditch to form the extension. A firm key between the existing concrete and the pressurized timber extension can be provided by bolts grouted into the end of the concrete to receive the laminated timber and into which the nuts of these bolts can be countersunk. The balance of the laminations can then be assembled and attached thereto. Top and bottom panels interlock with the side panels.

In fact, where necessary, a completely new pressurized laminated timber culvert could supply any replacements needed.

Median, Roadside, and Airstrip Drainage (Runway Drain)

Speaking of laminated culverts leads me to discuss a new product that may solve someone's problem. It is frequently necessary to quickly drain areas where runoffs might normally become ponded, such as in depressed median strips, runways, or airplane taxiing strips, underpasses, etc. Normally, this is done through ditch type drains or infiltration drains wherein a perforated pipe or stones are laid in a ditch and backfilled with stones or gravel. Dust storms, silt, and similar conditions can quickly block these ditches and render such drains inefficient. On the other hand, a narrow pressurized laminated culvert type drain with bevelled slots in each top lamination, which is installed flush with the pavement or at grade, and which can be of increasing depth (from 18 inches to 5 feet) at stated intervals until the take-off point is reached, provides immediate entry and drainage of the runoff regardless of the rainfall rate (up to practically cloudburst capacity) as the hydraulic capacity of the slotted surface is more than ample for all normal conditions.

Incidentally, these bevelled slots will not clog. Openings are each 1/4 by 2 inches on the surface and 1/2 by 2 inches at the base of the lamination. Anything that will pass the 1/4-inch opening will automatically be swept into and along the drain.

These surface laminations are installed in panels each 4 feet long, and they can be raised therefore at any point along the entire length of the drain for clearing any silt or obstruction collecting at any point in the base of the drain. Surface drainage is available nearly as quickly as the ditch can be dug. Also, being of laminated construction, the sides act as infiltrators and thus quickly reduce the water table within the depressed area.

Where infiltration drains are needed, such as in low-lying, swampy, irrigated, or similar areas, a new method of accomplishing such drainage is by using a low cost airway drain. This is a box type drain constructed of pressurized lumber, using two pieces of dimension lumber as the longitudinal sides and bevelled 1-inch lumber laid laterally as the top and bottom. By nailing the bevelled pieces in the same manner, a delta opening is obtained at each end of each piece, thus enabling the infiltration. This infiltration can be obtained at either or both top and bottom. Where conditions necessitate a closed type drain in the same run, such as through a clay deposit, it can be obtained by merely nailing the top and bottom bevelled pieces alternately opposite each other.

Drain capacities equivalent to or greater than the normal 6-, 8-, 10-, and 12-inch diameters can be standardized by using 6- or 8-inch sides and varying the span of the top and bottom pieces.

Incidentally, wood that has been surfaced or dressed has a much better hydraulic coefficient than even smooth, clay tile. Wood drains, therefore, have greater capacity than other materials of equal end area. Being available in normal lumber lengths of 16, 18, and 20 feet enables speedy installation, and their service life is permanent. Nearly 100 percent salvage is obtainable should future changes in location prove necessary.

Buildings

Pole type or rigid wood post construction for equipment sheds, maintenance buildings, sand sheds and, in fact, any type of utility or industrial building or even homes and small offices can be utilized. It merely consists of setting the pole or sawn timber post in the ground in the same manner as a powerline pole, only instead of hanging wires and cables on them, we hang the roof and walls.

That it is an efficient, economic method of construction is illustrated by: transit sheds at Longview, Benton County buildings, Washington County fairgrounds, Clark County fairgrounds, Douglas County fairgrounds, Oregon State University agricultural buildings, Oregon State Highway Department sand sheds, home of Herbert Sinnard in Corvallis, and Award of Merit residences in California.

NEW MATERIALS AND METHODS
Testing Equipment

Ray Schwegler

INTRODUCTION

It is difficult to say that any particular test for materials is new. Most tests start in a rather crude form and are refined and improved by a number of people. Tests generally are accepted after a lot of trials and correlation work over a period of years. Some of the tests I will discuss may be new to field engineers, but they are probably "old hat" to testing engineers.

Details of materials tests are spelled out by the American Association of State Highway Officials (AASHO), the American Society for Testing Materials (ASTM), and other agencies. Such details are of interest to the technician performing a test. I will try only to describe the general features and mechanics of the tests.

There is a real need for rapid, practical field control tests to control the quality of materials used in our highway construction. The highway contractor must maintain a high rate of production if he is to operate efficiently and economically. He will place several thousand cubic yards of material in an embankment, or produce and place several thousand tons of surfacing or pavement in a day. We need field control tests which can be completed in minutes, or at most an hour. Otherwise, we either must delay the contractor's operations or sacrifice proper material control.

NUCLEAR TESTS FOR DETERMINATION OF DENSITY AND MOISTURE CONTENT

We all have read about nuclear devices for use in determining the compaction and moisture content of embankments. Such equipment is on the market and has been used experimentally for several years. This equipment operates in the following manner.

Density Probe

1. Operates entirely on the surface of the material to be tested.

2. Radioactive source used is 3 millicuries of cesium

137, whose half life is 33 years.

3. The detector is a Geiger tube much the same as a Geiger counter.

4. Gamma rays are emitted by the source into the material being tested. Some rays are absorbed and a certain percentage are reflected back or "back scattered" and detected by the built-in Geiger tube.

5. Rate of back scatter is low in dense material and high in low density materials.

Surface Moisture Probe

1. The moisture probe also operates entirely on the surface of the material being tested.

2. Radioactive source is 5 millicuries of radium beryllium having a usable life of 1620 years. This source emits fast neutrons.

3. Most hydrogen atoms in the soil mass are in the water molecules of soil moisture. When a fast neutron strikes a hydrogen atom it decelerates and becomes a slow neutron. The back scatter of slow neutrons is measured by the equipment. Density tests can be completed with nuclear equipment in 12 to 15 minutes, rather than the several hours to one day required by standard equipment.

A study conducted by Colorado, comparing this equipment with their standard sand density method, found favorable comparison on 85 percent of density tests and 94 percent of moisture tests. This equipment used by Colorado costs about $4400. Other equipment is being developed.

Moisture Determination

In the field of standard compaction testing and control, moisture determination is often a time-consuming operation. We can dry soils in an oven, over an open stove, or by burning with alcohol. None of these methods is really rapid.

A fairly new method of moisture determination is the addition of calcium carbide to the moist soil sample. The moisture present combines with the calcium carbide powder to form carbide gas, and the amount of gas formed is directly proportional to the amount of water available in the sample tested. A definite weight of soil and a specified change of calcium carbide is introduced into a calibrated pressure cylinder and thoroughly mixed by shaking or tumbling. The carbide gas formed due to the water present is measured by a calibrated pressure gage reading in percentage of moisture.

Granular, fine-grained soils can be mixed readily with the calcium carbide powder. When clay soils are tested, a 1-inch round steel ball should be included in the cylinder to break down the lumps and soil clods and assure a thorough mixture of the materials. Corrected calibration gages are available to correct for the volume of the added steel ball.

We do not have much success in compacting embankments unless the moisture content is close to optimum. We can determine optimum moisture for a soil by pounding out a proctor curve. The soils placed can be sampled and dried to check their conformance in a slow, time-consuming process.

Mr. Collins of the Oregon Highway Department testing laboratory has developed a fast test for controlling the moisture content of most types of embankment soils within practical limits. This method sets an upper and lower limit for moisutre content for field control, and can be performed in about 10 minutes.

Lower Moisture Limit

Soil must contain enough moisture so that a handful of soil when squeezed tightly in one's hand will form a "cast" and will not fall apart when picked up with the index finger and thumb.

Upper Moisture Limit

Soil must not be too wet or muddy. A sample of soil is compacted in a Harvard compaction mold. If the compacting tool penetrates less than 1/4 inch into the compacted sample under a pressure of 37-1/2 pounds, the moisture content is satisfactory. If the compacting head penetrates the sample more than 1/4 inch under this pressure, the material is too wet and should be aerated or dried in some manner.

FOUNDATION SOILS

The Oregon Highway Department has developed a simple field test to evaluate the supporting power of a foundation material to support a fill. This device consists of a cone-shaped head, 1 inch in diameter, attached to a sounding rod. Pressure required to force the cone into the soil is measured by a proving ring, and the supporting power of the soil is measured by this method. A resistance to penetration of 140 pounds on the 1-inch cone is rated as firm. Such foundation material should support an average low roadway fill.

Let us move into the field of bridge design. We often must decide whether or not we need piling under a bridge footing and, if so, how long should the piling be to develop the proper bearing.

A recent test method is based on the effort required to drive a 2-inch OD standard penetration split-tube drive sampler. The sampler is driven with a 140-pound hammer with a 30-inch free fall. Foundation material is classified on the basis of the number of blows required to drive the 2-inch sampler 1 foot into the material.

The number of blows per foot can be converted readily into the minimum length of pile required for a cohesive or a granular soil. It also can be converted into safe allowable design loads for spread footings from convenient charts.

We may wish to test a completed highway pavement to predict its future behavior and measure its load-carrying ability. The Benkelman beam will measure the deflection caused by a known wheel load, and we will then know whether the deflection is within safe limits or excessive. With this information we can predict the future behavior and probable life of a pavement under legal traffic loads.

Asphaltic concrete pavements should be rolled and compacted to form a dense watertight mat. It is difficult to measure the effectiveness of a roller and to determine when sufficient compaction has been obtained. Pavement density can be correlated to either water permeability of air permeability. Excellent results in this field are being obtained with air permeability equipment developed by the California Research Corporation.

KINEMATIC VISCOSITY

You have heard Mr. Lovering describe the new asphalt specifications this afternoon. Kinematic or absolute viscosity measurements are a part of the new specifications. The kinematic viscosity measurements at 140 degrees F for liquid asphalts will replace the present Saybolt-Furol viscosity measurements at temperatures of 77, 122, 140, and 180 degrees F. The Zeitfuch cross-arm capillary viscometer is much more accurate, cleaner, and faster than the present test method. An operator can run five samples of asphalt by kinematic methods while he is running one sample by the Saybolt-Furol viscosity test.

DEGRADATION

Many highway departments are becoming conscious of the problem of degradation of aggregates. Materials which meet all standard test requirements become plastic and develop excessive amounts of fines after several months of service on the roadway. Our problem is the development of a test which will predict this behavior in advance for a substandard aggregate.

Oregon has developed a test whereby the aggregate is agitated in water by jets of air. Washington places aggregate and water in glass jars in a paint mixer or "roller." Idaho has developed a machine to produce alternate cycles of freezing or thawing. The standard sodium sulfate soundness test and the Los Angeles abrasion test without steel balls also are used.

All of these degradation tests show promise, but further correlation with actual field behavior is needed in most cases.

The sand equivalent test for the quality of surfacing fines, plant mix aggregate fines, or concrete sand, is used in several states. This test serves the same purpose as the liquid limit or plastic index tests. The test can be performed in 30 minutes by unskilled help, and it has real merit as a field control test.

We can use the Washington method for rapid field determination of the cement content in Portland cement stabilized bases. Certain components of Portland cement are water soluble, and the soluble materials affect the electrical conductivity of water. The relative conductivity is related to the amount of cement present in the sample of fresh concrete tested. There are many areas where we must use Portland cement with a low alkali content, expressed as Na_2O and K_2O.

Idaho checks the alkali content of each load of Portland cement delivered to a highway job. Use of flame photometry equipment permits one operator to run alkali determinations on up to 30 cement samples per day. Our present day Portland cements attain high early strengths due to fine grinding of the cement clinker. New tests for fineness of grind utilize the turbidimeter test and the air permeability tests.

Let us look at Portland cement concrete testing. We can replace our old slump cone with the Kelley ball test for slump, and save a lot of time and effort. There are several devices for determining the amount of entrained air in fresh concrete mixtures. The Chase air meter is quite useful for field control testing. The test is simple, rapid, inexpensive, and easy to perform with reasonable accuracy. The Swedish hammer impact test will give us reasonable data on strength of concrete in place in a structure. This is a rapid nondestructive test. Sonic testing devices will measure strength of concrete specimens without destroying the beam and permit retesting at later dates.

New tests have been developed to assist in the design of base courses and pavements. We have the triaxial test to measure the strength of subgrade soils or aggregates. The Hveem stabilometer is a similar test and includes asphaltic pavement design. The Marshall test is used for field control of bituminous pavement mixtures. The North Dakota cone-bearing test also shows promise in these fields.

Our estimate of the effective life of a metal culvert at a given location is often just a rather wild guess. How long should such a culvert last? The California Highway Department has developed a method of culvert design based on tests at a proposed site.

1. The pH value of the soil at a site is measured. They determine whether the soil is acid, alkaline, or neutral.

2. Electrical conductivity of the soil is measured with simple meters.

With this information and general flow data, California claims that the effective life of a plain, galvanized metal culvert or an asphalt-coated culvert can be predicted quite accurately at any given location.

New products, methods, and materials are appearing every day on the market. A few recent ones are: aluminum guardrails, aluminum culverts, A-36 structural steel, high-strength bolts, high-strength prestressed wire, neoprene bridge pads, epoxy resins, new welding techniques, air entraining agents for concrete, retarders for concrete, quality asphalts, cationic emulsions, rubberized asphalt, colored asphalts, anti-stripping agents, new paints, base stabilization—cement, asphalt, or chemicals.

These products and methods are useful and represent real progress in many fields. Such materials often require entirely new tests and specifications to assure quality control. Many of our new tests are still in the research status. Others are highly technical and of little interest to this group. For example, such materials as air entraining and retarding admixtures for concrete, antistripping additives, curing agents, paint resins, and other complex chemicals are evaluated by use of ultraviolet or infrared light with a spectrophotometer.

The engineering profession lives with many unsolved problems. The materials engineer and the testing engineer probably have more than a fair share of these problems. There is a crying need for both basic and practical research to solve existing problems and meet new problems encountered in our rapidly changing technology. These problems include proper specifications for materials and rapid suitable tests to control quality. We are making progress, but we still have a long road to travel.

THE CHALLENGE OF TODAY'S HIGHWAY PROGRAM

Ellis L. Armstrong, President
Better Highways Information Foundation
Washington, D.C.

Today, in our highway program we have a real challenge, one that requires our collective efforts and abilities and integrity and dedication. Our automotive age in these days of increasing urbanization has produced problems of great complexities; problems that run the full gamut of the physical, social, and economic fields. Actually, our present highway program is a real testing ground for our democratic form of government—testing whether or not such a government with its wide dissemination of responsibility, actually requiring ultimate decision by the individual, can meet the needs of the whole society—whether those decisions of the individual can be based on sound information and understanding—and whether each of us as individuals measures up to the responsibilities that we have as a part of our free society.

We now have well under way the world's greatest peacetime public works project to bring our highways up to date in this automotive age. It is an ambitious undertaking, but one that is economically and socially sound, basic to our very way of life, and one that is a must for progress. And we need to view it in proper perspective and keep this perspective up to date in our fast changing times. We now have over 76 million automobiles, trucks, and buses on our highways, and we are traveling about 740 billion miles each year. In making this travel we spend directly over $80 million. An operation of this magnitude presents wonderful opportunity for prudent investment to yield rich returns, and that is exactly what our accelerated highway program is.

Perspectivewise, here are a few items we must keep in mind. For instance, some few critics look aghast at our highway transportation operation and loudly proclaim we are spending too much on transportation for our good. However, they overlook the fact that transportation is part of the productive process; we consume transportation in producing goods and services. Our mobility and the freedom it gives us for optimum utilization of our human and other resources is the "goose that is laying the golden eggs." The relationship between travel on our highways and our total production of goods and services has remained fairly constant over the years, being 1.4 to 1.5 miles of travel on our highways for each dollar of goods and services produced.

We cannot forget that last year we killed in highway accidents over 38,200 of our friends and neighbors, and injured over 1-1/2 million more. The direct cost of these accidents is calculated at over $7 billion a year. A recent study by the Bureau of Public Roads shows that accident insurance premiums that you as an average motorist pay today are equal to an 18¢ tax on every gallon of gasoline which you consume. These accidents can be drastically reduced by construction of highways adequate for the traffic they carry.

Other factors than the highway are involved in accidents, of course, but I was very interested last month in reading a report on highway accident problems in Italy, and I quote: "In 80 percent of the cases casualties can be traced back to violations of traffic regulations and carelessness; however, it is known this type of behavior is seldom observed with an efficient road system."

A recent detailed study of accidents in England suggested that had the roads been built to standards considered adequate for the traffic being carried, perhaps as many as three-fourths of the accidents would not have occurred.

Modern, adequate highways reduce accidents by reducing and eliminating conflict areas and minimizing decisions that must be made by the motorist. Records to date indicate that the accident rate on controlled access highways is reduced to one-third or less of the average of all roads, and the death rate is reduced to at least one-half of the average. It has been estimated that completion of the Interstate alone, which will carry only 20 percent of the total traffic, will save at least 5000 lives per year, and some more recent studies have increased this estimate to as high as 9000 lives per year. With all our highway systems improved, the saving in lives will be many times this number.

We need everyone to get a realistic appreciation of the true economy of our modern highways. Too many worry about the cost per mile of construction, rather than the cost per unit of service provided, which is the correct measuring stick of good design and efficiency. With our modern, controlled-access Interstate roads we are getting a real bargain. The cost per vehicle-mile of providing these roads, including capitalization of construction costs, operation and maintenance, and all other costs, is only 0.4¢ compared to 0.7¢ per vehicle-mile on the remainder of the Federal-Aid primary system, and 1.2¢ per vehicle-mile on our Federal-Aid secondary system. In addition, the users of these highways save, including a conservative allowance for time, from 2¢ to 4-1/2¢ per mile traveled, depending upon the facilities replaced.

Even with our present expanded highway improvement program, we are spending a smaller fraction of the highway transportation dollar on highways than we did before World War II. Besides the driver, there are two factors in highway transportation: one is the vehicle and the other is the road. Today, we are spending only 12¢ of the highway transportation dollar on roads, as compared with 14¢ to 15¢ in the 1920's and 1930's.

Good progress is being made on our accelerated highway program. Over 12,000 miles of the 41,000-mile Interstate System scheduled for completion in 1972 are open to traffic, and construction is under way on another 5000 miles. Since launching of the program in 1956, 150,000 miles of regular primary, secondary, and urban Federal-Aid highways have been completed, and another 20,000 miles are under construction. Progress has been made on non-Federal-Aid highways, roads, and streets. Here, in the Northwest, your progress has been somewhat better than the national average. Progressive highway leadership, such as that provided by Sam Baldock, Bill Bugge, the late Dutch Williams, and many others resulted in your getting after the highway problems somewhat ahead of many other parts of the country.

Today, here in the Northwest as well as all across the nation, we are in a better position than ever before to do a good job of providing highways for the greatest good to the greatest number. We have the tools, techniques, analysis, information, and know-how to get the job done.

We know, for instance, that good highways today pay for themselves in direct savings to motorists. They are excellent investments. Detailed studies of all improvements on the Federal-Aid system completed since passage of the record-making 1956 Federal-Aid Highway Act show that the benefit-cost ratio of the direct savings to motorists because of highway improvements is better than 3 to 1. This is in addition to the extra dividends of savings of human lives and suffering through the reduction of accidents, the opening up of new opportunities for growth and development, the rejuvenation of areas served by the better highways, the savings in time and jangled nerves, and the increased joy and happiness in motoring on an adequate highway system.

We know fairly well what the highway needs are. The state highway departments and the federal government, cooperating with counties and municipalities, have been collecting, analyzing, and evaluating detailed information all across the nation concerning the problem of transportation. From these data, including travel origin and destination studies, future growth patterns, probable land use, economic changes, best community planning, and other pertinent factors, travel desire lines are formulated. These studies were started in the 30's, and have been continued since with increasing effectiveness and sophistication. Today, the electronic computer, for example, makes it possible to carefully analyze millions of pieces of data and evolve the resulting travel patterns with various transportation facility plans and take into account all the possibilities of growth patterns.

Across the nation we have many examples of community-state-federal cooperative planning for optimum highway facilities for growth in the years ahead. The studies you have under way in Salem, in the Portland metropolitan area, and in the Puget Sound Regional Transportation Study, are good examples of this type of cooperation. These studies involve cities, counties, states, and several agencies of the federal government, pooling their efforts to come up with the best solutions. This is good for the transportation problem but, even more important, it demonstrates that our form of government will work, and that individuals can and will cooperate to resolve their mutual problems. This makes for progress and speaks well for the future.

We know how we can most effectively meet the traffic requirements. Our geometric and structural design techniques, combined with judicious use of controlled-access principles and the use of single-purpose freeways for the moving of large volumes of traffic, along with major arterial streets, collector streets, and the remaining roads and streets, to give a balanced system, demonstrate the know-how to resolve the problems. Further, the planning includes various modes of mass transit in the larger metropolitan areas where the needs for these facilities exist.

Advances in design techniques have been tremendous. Use of photogrammetry and the high-speed electronic computers makes possible more thorough, more intensive, and more extensive economical, location, and design studies. Continual progress in development in materials and of construction equipment and techniques, makes possible the continuing economy of good highway construction.

If all this is so, then where is our present challenge in the highway program? Just keeping the program going is a great challenge. A project of this magnitude does not just happen to keep rolling after it is started, but takes continuing and increasing efforts all along the line. I believe, however, there are two areas that right now present perhaps our biggest challenges. One is the need to keep progressive and up-to-date, to adopt new methods, new techniques, new approaches to our problems as soon as it becomes apparent that we can thereby do a better job, faster, and with less cost and effort. In these fast-changing times it is necessary to run at top speed just to stay even. Tradition and prejudice often can prove to be blind leadership. Great losses can be inflicted by frozen adherence to outworn concepts and methods. It is necessary to keep a fresh outlook and fully appreciate that change is constant.

You folks recognize this and are doing something about it, as evidenced by these yearly conferences. We need the type of communication with each other that these conferences afford in "getting the word" about problems and new developments. Here, all members of the highway team—the administrators and engineers from all levels of government, the contractors, and the material and equipment suppliers can compare notes and increase understanding and improve relationships. All of you have a vital part in the highway program, and all of you have vital contributions you can make to further progress.

Discussions so far in the conference have been excellent. The problems of specifications, adequate construction control, construction contract administration, new materials and new methods, all of which have been discussed, show that you are taking after these challenges. This problem of specifications and adequate construction control is a major one in our program.

Requirements today for the completed roadway are greater than in the past because of high-speed, high-volume traffic. The margin for error and variables and uncertainties we used to have are no longer present. You engineers must know what you want and when and where you want it, and have your specifications so state, specifically and clearly. Specifications must mean what they say, and then the field engineers must see to it that the requirements are met. You construction contractors and material suppliers, in turn, must understand the specifications and expect to conform to the requirements.

All of this, of course is elementary, but we need periodically to review quite carefully this problem and be sure it is being adequately handled. We also need to keep in mind that providing most economically an adequate highway system requires careful, continuing cooperation of all members of the highway partnership, including legislators, administrators, engineers, contractors, and suppliers—actually, everyone else, for we all are involved.

The other area that presents challenge, perhaps our greatest challenge, is that of getting and keeping public understanding and support of the program. Planning, designing, and construction of our modern highways have become quite complex and do not lend themselves to uniform snap judgments. As just mentioned, whether we like it or not everyone these days is directly involved in the highway program, all are affected, and each somewhat differently. Thus, the problem of keeping support of a program resulting in the greatest good to the greatest number is a real one.

Our roads, like other public projects, are under democratic control, and our democracy is government of, by and for the people. The individual citizen, as someone ably pointed out, is the ruler and the ruled, the law-giver and the law-abider, the beginning and the end, and the government at Washington, D. C., or at the state level, or at the local level, cannot be any wiser than the people.

Actually, the real road builder in the great Northwest, as in the rest of America, is individual John Q. Public. He may not appear on the right-of-way with his pick and shovel, as our grandfathers did in working out the road tax, but he pays for the job and he is the ultimate authority on the decisions. So, even though the engineers in the highway departments who are directly involved in designing and building our modern roads are convinced that proposed road plans are right, the plans cannot be accomplished until favorable judgment is also passed by the individual citizen.

Getting this favorable judgment is not easy. As an example, while I was U.S. Commissioner of Public Roads, one of my duties was to serve as a member of the Planning Commission for the Washington, D.C., metropolitan area. After many years of discussion and over three years of intensive study by several firms of the best planners and engineers in the nation, a general overall transportation plan for the nation's capitol was adopted. As commissioner, looking at the overall picture, I was convinced the plan was sound and right. As the resident of 6511 Dalroy Lane in Bethesda, I did not think too highly of it, for I had to drive 2-1/2 miles in the wrong direction to an interchange before I could get on the freeway. One of my friends opposed the plan vociferously because the freeway was located just beyond the property line of his lot. Also, there were several neighborhood protective vigilante organizations who had definite ideas about certain sections of the freeway plan that were far from complimentary.

Even after a plan is adopted, whether local or national, it is not automatic that it will be accomplished. It is under continual scrutiny and reappraisal which, of course, is good for this tends to make doubly certain the plan is right. However, great care must be taken to keep the overall plan understood. A small, well organized minority can wreak havoc with any program if we have indifference or lack of understanding of the majority of our citizens. I think we all agree, eternal vigilance is the price of liberty, but it is also the price of keeping a sound program adequately supported by public opinion. To be successful, the program must have the full support of an enlightened citizenry. Neglect of this understanding will nullify even the best of your plans. For government as we have in America, in the last analysis is organized opinion.

About three years ago, a group of national highway leaders realized that more positive action was needed nationwide to keep people informed about the road program. Too much misinformation, distortion, and complete lack of information were threatening to nullify efforts to meet the expanding highway needs. As a result of this concern, and after a great deal of effort, the Better Highways Information Foundation, a nonprofit, public service organization, was established with headquarters in Washington, D.C. Its entire purpose is to sponsor, assist, and correlate nationwide on a program to search out and disseminate sound, unbiased, factual information on highway needs, benefits, and progress. The objective is to assist in getting "grass roots" understanding of America's highway program.

Operations got under way in July 1960. Since then, BHIF has been reaching the public through national media and through interested groups, and contacts which have been established in all states, in addition to working with all the state highway departments. The local groups adapt and distribute materials in their own areas and communities. The effectiveness of the state groups has been excellent, generally, and there have been substantial accomplishments.

The first National Highway Week last May was sponsored by BHIF, and focused nationwide attention on the importance of highways to American life. In his proclamation for Highway Week, President Kennedy encouraged all Americans "to judge the value of highway transportation to their own activities and to our national welfare," and this theme was echoed by the state governors and several hundred mayors. The second National Highway Week is coming up May 20-26, 1962.

The Foundation has been culling and arranging a mass of technical, statistical, and legal data about highways into information kits and releases. As useful techniques for reaching the public are found and perfected, the "how-to" details are distilled and the information is circulated to the many outlets for highway information across the nation. More than 800 pages of data have been turned out.

Such things as encouraging well written, factual stories about highways in major magazines of national circulation and promoting and assisting with national TV programs have resulted in many millions of people having the positive side of highways drawn to their attention. A 17-minute color and sound film telling the highway story of the commuter and businessman has been produced and is being distributed nationally. Two large animated public exhibits are being shown across the nation at state fairs, conventions, auto and home shows.

Formation of state information groups to utilize BHIF data and adapt it to local problems and to work with state highway departments and thus become spokesmen for better highways at the state level has made good progress, and over 30 such information groups are now working with BHIF.

The first National Workshop on Public Understanding was organized last year, sponsored jointly with the American Association of State Highway Officials. Seventy-six representatives from 33 states aired common information problems, explored and shared techniques, and clarified the long-range objectives of getting sound factual public understanding of better highways. The second workshop was held three weeks ago in Kansas City, and had participation by over 100 representatives from nearly all the states.

These, and many other activities of the BHIF have assisted materially in getting an improved appreciation and understanding of what better highways mean to our whole economy and well being. I think that there is now general recognition and appreciation by all the highway fraternity that one of the big problems in providing the desired end result of adequate highways for modern-day growing America is proper public understanding. I think, generally, John Q. Public has improved his ability to judge by being a little better informed, but there is still much to be done. For one thing, understanding is a temporary thing and tends to fade away like a morning mist. Continual, unrelenting effort is needed to keep the problems and solutions in perspective.

The stakes are high and the challenge is great. If we provide an optimum highway system to meet our needs, our economic and social growth and development will progress with resulting opportunity for a better life for all. If we fail, growth and development will be stymied and delayed, and the inexcusable waste of an inadequate highway system will be continued.

Further, in time of national and international crisis, a dependable, high-speed, high-capacity road network is a must to move raw materials from source to production center; to move goods quickly from one processing plant to another; to move troops and military equipment; to rush aid to a stricken city; or to evacuate a given area. The President's Advisory Committee reported, "A safe and efficient network is essential to America's civil and national defense . . . The existing system is inadequate . . . It must be improved . . ." With our present missile race, the mobility provided by expressways takes on a new and added significance.

Keep in mind that we all are involved, not only in the program in our own area or state, but nationwide as well. Our highways today have made all of America pretty much one big neighborhood. Industrywise, because of our highways, our nation has become one big assembly line for production. Progress or lack of progress, in any section of the country has an effect on all the rest of the nation. Whether we like it or not, we all are involved in highway progress in Maine, in Kansas, in South Carolina, in Florida, as well as the great Northwest and in all the rest of the country.

I believe this challenge will be met and required understanding will be obtained and maintained so that the highways we need will be built. Collectively, I am sure we are not so stupid as to lose out by default. It has been said time and again, and it is more true all the time with our ever increasing highway travel, that we pay for good highways whether or not we have them, and we pay much more when do not have them through increased driving costs, lost time, property damage, and human lives lost by accident which can be drastically reduced with adequate highways.

During the past four years as I have traveled up, down, and across America, I have developed a sound, dynamic enthusiasm for the accomplishments of our highway program throughout the nation. The tough problems that are being overcome by realistically facing up to them and cooperatively setting out to resolve them, speak well for our democratic way of life. The progress that urban areas are making in overcoming decades of highway neglect and failure to plan and build for the days ahead, is good. Cities are not doomed as some suggest. As the highway improvements begin to fit together to become an operating system, various urban areas are taking their places as up-to-date parts of the Twentieth Century.

The rejuvenating effect on area after area of the highway improvements all across the nation is wonderful. The individual citizen's increased freedom that better highways bring is broadening his area of influence and his opportunities for social and economic betterment. The changes are being, and will continue to be met. The days ahead look good.

URBAN-SUBURBAN STREET IMPROVEMENT STANDARDS

General Reporter: D. W. Loutzenheiser

INTRODUCTION

It is a real pleasure on my part to be with you today as we deal with the general topic of Session No. 5. The business of serving as a "general reporter" is a new but interesting assignment for me, and I expect this session conduct format is new to many of you. Evidently it is common European technical meeting practice for I have noted or read the reports of such sessions over a number of years. As they seem to do it, about a half dozen papers are scheduled, and by some process relatively unknown in this country, the authors complete their papers two or three months prior to the meeting. The papers are distributed to all who might attend and there is ample time for all to leisurely study them, collect their thoughts, and prepare to engage in a lively and perhaps challenging open discussion with the author at the meeting.

In this arrangement, the authors do not read their separate papers at the meeting. Instead, a secretary, or where there is more than one on the same subject, a general reporter presents a relatively brief or refresher summary of their content. In this process he may choose to interject some of his own views. Most of the meeting time then can be used for open discussion between the attendees and the authors.

Today, we go at least part way in such arrangements. The authors are present but will not read their papers personally. I am asked to cover the ground for them. However, since there are only three papers, and more importantly, since few if any of you have had an opportunity to review their papers, it seems desirable that I report them rather fully rather than give a brief digest. They, of course, will have an opportunity to amplify my statements as they may desire. As I present their views and data, you should be making notes, mental or otherwise, on features to be discussed later in the session.

To start let us orient on the general subject,"Urban-Suburban Street Improvement Standards." Obviously, we are to consider the whole of the urban area; both the heavy inner and lighter fringe portions. By use of the word "street" it is evident that we focus on the ordinary ground-level facilities rather than on the supers or freeways, but we should recognize that there is more than one kind or level of street. "Improvement" connotes the redoing of something that previously existed, but I am sure it was not intended to rule out original or new construction of a street. Everyone knows what "standards" mean. Usually they are a fairly definite set of dimensions, criteria, or values that spell out what is to be done where. They generally are stated as floor or minimum values, but sometimes upper or ceiling controls are fitting. Also, there may be governmental level distinctions, as well as city, county, state, or federal. We should not limit our thoughts to any one since all levels engage in street improvements. In total, the field we are discussing is the space and depth that should be named and used as controls to build our streets. How do we establish control values? What are they? What groups or separations are needed? Are they forever fixed, once named? All such questions may not be answered, but they are involved.

This is pretty much a game of dealer's choice—most of you have your own standards as used by the city, county, or state. There may be different standards from a planning and construction viewpoint. We have no national standards in this field, but both AASHO and NCUT have produced guide values. So, governmentally speaking, of necessity we must work from the ground up, rather than from the top down.

(The ensuing three papers were presented at this time.)

CLOSING SUMMARY

The major contents of three good but decidedly different papers on the session subject have been given. As the program arrangers doubtless had in mind, each emphasized different features that are significant parts of the subject. Kennedy and Homburger dwelt on the features of access to abutting land as stage setting for a review of what access controls can be worked in to expedite through movements. They held off on specific standards, but referred to NCUT guides for evaluation of local values considered for use.

Sawhill brought out that neither the land-use nor the highway plan comes first—they should be worked out together. He made clear that classifications are essential to set up standards; type or street system and character of urban area were two such class groups. ADT volume groups also were given. After reference to NCUT values, he presented a set of standards in cross-section form, including pavement designs.

Ross made a plea to consider the future needs, reflecting current problems to remake cramped streets into at least tolerable facilities. He presented the Idaho urban arterial cross sections, all of which are relatively high type, beginning about where Sawhill ended but without classification groups other than geometric totals. He also touched on land-use tie-in and introduced factors of parking space, public reaction, funds available, and conversion means such as parking restrictions and one-way couplets.

It is worthy to note that all three papers to some extent touched on several basic items or points in setting up street standards. In combination, the three gave the subject a good going over. To make a summary of the whole, let me spell out my idea of an approach to use in setting up urban street standards.

Of necessity, an urban-suburban street design standard must be more than a cross section for stated volume groups. The conditions along the street also must be spelled out. Included are intersection layouts; type and extent of traffic controls and devices; frequency and details of driveways, alleys, etc.; parking-stopping-standing controls; pedestrian facilities, especially those across the street; and the extent of left turns sanctioned. All of these together result in a "type of operation" and stem from the land service features along the street. To a large extent, these features have been bunched in definition statements. We can call it a classification plan.

Planned Service Functions

The following "planned service functions" given in NCUT Manual 7A are definitions for street groupings:

1. Expressway system - providing for expeditious movement of large volumes of through traffic between areas and across the city, and not intended to provide land-access service.

2. Major arterial system - providing for through traffic movement between areas and across the city, and direct access to abutting property, subject to necessary control of entrances, exits, and curb use.

3. Collector street system - providing for traffic movement between major arterials and local streets and direct access to abutting property.

4. Local street system - providing for direct access to abutting land and for local traffic movements.

These NCUT concepts are very similar to the AASHO definitions, except that the latter does not separate the intermediate (collector street) group.

1. Major street - an arterial highway with intersections at grade and direct access to abutting property on which geometric design and traffic control measures are used to expedite the safe movement of through traffic.

2. Local street - primarily for access to residential, business, or other abutting property.

Kennedy's Figure 1 schematic classification diagram assists considerably in the understanding of these groupings.

In the NCUT Manual 7A, Figure V on page 10 is a diagrammatic layout for a residential area, showing a nonrectangular pattern for a total street system, with their four groups separately indicated. This pattern may be warped to fit the valleys, ridges, railroads, waterways, coasts, street grids, and other governing features, and it is representative of your own city. The total traffic needs of the developed city call for the whole system, not just some of the parts. Smaller cities may not have expressways, but all require the lower order of streets. Provision of collector and local streets is easy, since they give access to abutting property. Development of arterial streets, with some denial of access details, is more difficult, however. An important point is that to handle the total transportation needs, some of the system must be arterial streets; the whole system cannot be the land access types.

This raises the question of just how much of the total system should be arterial streets. Since conditions vary widely, there are no pat answers to this. NCUT Manual 7A includes the following table in an effort to be helpful. Note that the major arterial and collector streets are combined, since data to separate them were lacking. These are typical, not positive, values, but are generally helpful.

Suggested Division of Street Mileage

Population of metropolitan areas	Percentage of mileage in each system: Expressway	Major arterial & collector street	Local
Under 25,000	*	25 - 35	65 - 75
25,000 to 150,000	*	20 - 30	70 - 80
150,000 to 500,000	*2 - 5	20 - 25	75 - 80
Over 500,000	*5 - 8	20 - 25	75 - 80

*Percentage of expressway system mileage will vary from city to city, depending upon amount of through traffic, deficiencies in the street systems, topography, population density, and other factors.

The type and volume of traffic is another classification or grouping that must be worked in to set up street standards. For each of the system classes or types, the lane, intersection, and cross-sectional requirements can be further identified in capacity groups. Two or more subclasses in each type appear logical. Primarily, these show the number of through lanes. Sawhill showed examples of this and, although unstated, I am sure they are also used in Idaho.

It is then possible to detail cross-sectional element dimensions which establish basic minimum ROW widths. Sawhill's table shows the NCUT minimum suggestions. There is logic in the use of 10- and 11-foot lanes on lower order streets, but I agree with Ross that major arterials should have 12 feet. Curb parking lane or shoulder widths are generally agreed, and the indicated border area widths are commonly accepted values, perhaps more assumed than known. Median width is a hot subject in many localities; 4 feet is a common minimum and 16 feet instead of 12 feet as the next logical step. It is a dealer's choice on the median cross section since opinions across the country vary widely. The sum of all these dimensions should establish the ROW width.

Some thought should be given to separate dimensional standards for new as against existing streets. The new or build-for-the-future set is more the desirable order instead of the tolerable set that often must be used where existing ROW governs. All of us, then, should get at the business of reserving proper space out on the city edges before the land development takes place, not after. We should not want to put squeeze cross sections in these new areas.

Decision on street standards rests with the agency owning and operating the street and, as we have heard, it is to a large extent a local matter. This should not mean that the above processes do not apply just because the state or federal agency is not establishing or enforcing them. Any street ROW and section should be determined on some logical, planned basis.

Lastly, we must continue to work on the pressing current problem—how to get more traffic carrying ability in the major system of existing streets. This is a street standard problem also, but usually within a fixed ROW limit. Our job is to work out the best possible cross-sectional balance in the widths that are available or can be attained. Let us not forget that another street location may be the best way to solve the arterial traffic problem when the old or existing route is heavy on land service features.

URBAN-SUBURBAN STREET IMPROVEMENT STANDARDS

Urban-Suburban Arterial Street Improvement

Lewis J. Ross

This paper deals with the design and right-of-way standards for urban and suburban street improvement. Discussion is limited to the type of facility which is intended as an arterial or collector street as opposed to the ordinary residential and business streets or freeways and expressways.

The arterial street system has long been recognized by engineers as the backbone of urban transportation. This recognition, however, has in many cases not been reflected by the adoption of adequate right-of-way and design standards. Arterial street systems in the majority of our cities have developed as the cities themselves have grown, in more or less an unplanned manner. Consequently, we are now confronted with the situation of having a large number of major urban and suburban streets of inadequate widths located on narrow rights of way. Correction of this situation, especially in urban areas, has proven to be a very slow and expensive process. Thus, it is the intended purpose of this paper to stimulate interest regarding the adoption of right-of-way and design standards for urban-suburban arterial street improvements that will allow adequately for future needs.

It is recognized that each urban arterial street improvement project involves its own problems and peculiarities. However, the desirability of setting certain minimum standards is evidenced by the numerous problems which have arisen in recent arterial improvement programs due to lack of planning in the past.

The Idaho Department of Highways, in recognition of the need for certain standards, has adopted a standard policy as reflected by the accompanying exhibit of "Typical Urban Sections." This policy includes minimum standard widths for right of way, traffic lanes, parking lanes, medians, and border areas. It should be noted that certain absolute minimums are established. Traffic lanes of at least 12-foot width are considered essential for the orderly and safe movement of modern vehicles. Parking lanes, if provided, should be no narrower than 8 feet. Minimum widths for border areas are less definite. Eight feet are considered a bare minimum for the placement of sidewalks, underground utilities, utility poles, and drainage facilities in suburban areas. This 8-foot minimum, however, would be far from adequate in urban areas where large volumes of pedestrian traffic are involved. Approximately 16 feet is considered a minimum width for border areas in downtown and business areas. Idaho's policy also provides for the distribution of additional right of way over and above minimum requirements to the various components of the roadway section.

Strict adherence to a policy of this nature is, of course, very impractical. Each improvement project invariably has associated with it special problems which cannot be solved by a general policy. Thus, a policy should be recognized as a "guide" for improvement, not as a "rule" which sets absolute minimum standards, nor should it be recognized as a goal or objective. If this were the case, the role of engineering would be superfluous once a policy was established.

A number of considerations must be weighed in determining the final geometric section which best suits a given project or, for that matter, any portion of an improvement project. Usually, it is quite difficult to give any one consideration more weight than the others. Existing and estimated future traffic volumes usually indicate the number of traffic lanes that are desirable, if not essential. Traffic figures alone, however, should not be the sole criteria for determining right-of-way widths and street sections of a proposed or contemplated arterial improvement. Equally important are: existing and estimated future adjacent land use, traffic characteristics and adjacent street patterns, volume and character of pedestrian traffic, present and future availability of parking space and its location, desirability of providing parking, community reaction toward an improvement, and, finally, economic feasibility and availability of funds.

It should always be kept in mind that urban and suburban arterial improvements must serve traffic well into the future, possibly up to 25 and 30 years hence. Therefore it is desirable that improvements be made in a manner that will permit future changes at a minimum expense and a minimum disturbance to adjacent property. Because future conditions involving a street network may differ from existing conditions, ultimate development of a project may differ considerably from its initial operation. The most common occurrence which necessitates changes in operation is increased traffic demand on existing facilities.

One method of providing greater traffic capcity on a street network is conversion from two-way to one-way operation.

Cases where a future one-way grid system is contemplated should reflect designs flexible enough that the change can easily be made.

Another solution to the problem of providing greater future traffic volumes involves the removal of parking. It may be practicable to provide auxiliary or parking lanes in the improvement with the intention of ultimately securing this extra street width for additional capacity. Unfortunately, it is seldom an easy matter to remove parking from an arterial street in the areas where additional traffic capacity is most greatly needed. However, where improvements are financed with road user taxes, the parking of vehicles on such facilities must be regarded as a privilege by both the owners of adjacent property and the road user. The community should be advised well in advance when project development of this type involves the ultimate removal of parking. Where parking is considered essential, the alternative of providing off-street parking as opposed to on-street parking should be investigated.

The adoption of a "minimum standards policy" may appear a useless endeavor in view of the many considerations that must be taken into account in the development of each individual arterial improvement project. A "minimum standards policy," however, is defended on the basis that if applied it should tend to provide similar solutions to similar problems and, consequently, alleviate to some extent the unexplainable wide variances which are found in different street sections. The adoption and employment of such a policy should also provide arterial facilities which will serve traffic better for longer periods.

Perhaps, in conclusion, it would be well to review some of the broader aspects and problems associated with urban-suburban transportation and related street improvement. The primary objective of any arterial improvement project is, of course, to increase the traffic capacity of a street network, reduce delays to through and local traffic, and decrease accidents. Thus, it is the engineer's responsibility to accomplish this objective in the most economical manner, considering all possibilities. The overhaul and extensive widening of arterial routes may or may not provide the most economic solution. The best solution could possibly involve the construction of comparatively few miles of controlled access highways as opposed to an extensive arterial improvement program. The important problem to be solved is how to gain maximum rate-of-return on urban investment, not whether this street or that street has a width less than an established standard.

Another problem that possibly has not been given enough thought in the past is the matter of terminal facilities and their relationship to urban-suburban street improvement. It is recognized that terminal facilities in downtown areas and other major zones of origin and destination are as important to transportation requirements as are streets and roads. It is questionable, however, as to who should be primarily responsible for the development of terminal facilities. On-street parking is the commonly adopted method of providing terminal storage. The adjacent property owner definitely benefits from this arrangement, but for what share of its cost is he responsible? Also, can the revenues gained from road user taxes be justifiably expended for facilities which do not provide for the movement of vehicles?

URBAN-SUBURBAN STREET IMPROVEMENT STANDARDS

Design of Sections

Roy B. Sawhill

Introduction

The Highway Bill of 1956, which created 41,000 miles of interstate highways system, was a major stimulus for additional first-class highway construction. This is particularly true in the urban areas where construction costs are beyond the revenue resources of the city, county and, many times, the state highway department. The Federal Home Finance Administration has also provided federal funds through 701 programs, urban renewal, and other special studies, which are primarily slanted towards the urbanized areas. Although these latter sources of support for planning, engineering, and traffic studies have been a shot in the arm to the urban areas, the urban and suburban administrative officials still face the problem of deciding what type of study program to pursue.

Many times finances dictate that only a partial study or one part of a comprehensive approach to the solution can be performed at a time. One of these major decisions is to determine whether a land use plan should be pursued first or an arterial street plan. In some instances this is not a difficult problem because some municipal areas may have already had one or the other of these studies previously performed by their own staff, and so many of the planning or arterial street location problems have been ascertained. In other municipalities the land development and geography dictate that the land use and/or the arterial street network is partially predetermined. This is not always the clean-cut solution; therefore the officials must usually decide which comes first.

From observations of studies completed under this method of federal support, there is strong indication that when planners pursue the studies for the urban areas the major emphasis is on the land-use planning and zoning, but when engineers tackle the studies, emphasis is placed mostly on the arterial street location and design. Nothing could be more frustrating to the traffic engineer in attempting to design the proper location and type of arterial street network without information regarding the abutting land use and the character of the potential area development. Likewise, the planner is likely to be frustrated in attempting to do land-use projection studies and facilities planning without some basic concept of the requirements for an arterial street network.

Ideally, these two types of studies should be conducted as one package type of study. However, being more realistic, at least one of them should contain in the contract an agreement that the other phase should be considered at least to some limited degree. From this limited review subsequent studies could then make a more detailed analysis of the arterial street plan, the CBD plan, and traffic circulation or the parking requirements for the future.

The design of the cross section of a roadway is not merely a detail of design for the traffic engineer or highway engineer consistent with an arterial street plan, but is important also to the land planners in indicating to them the right-of-way requirements and the possible access control that will be necessary. This paper is intended to pinpoint the decisions to be made relative to right of way and street widths.

Design of Cross Section

From this preliminary introduction it is apparent that before the cross section can be ascertained, two classifications must be determined:

1. The kind of street as denominated by traffic use. This would be a freeway, an expressway, a major arterial, a secondary arterial, or a local access street.

2. The kind of area being served by the facility.

To illustrate Item 1 on traffic requirements, Figure 1 indicates in a diagram form the approximate average daily traffic-volume requirements consistent with six types of general street classifications. This chart shows that access streets can be expected to carry traffic volumes from 0 up to 2400 vehicles per day. Two-lane secondary arterials have a traffic volume ranging from 750 to 2500 vehicles per day, while major two-lane arterials will carry traffic volumes between 2500 and 4000 vehicles per day. Any traffic volume in excess of the 4000 not only warrants major arterial consideration, but also at least four-lane traffic carrying capacity. This information is consistent with traffic volume and street classification characteristics published as standards, not only by the federal government, but also by state and city and research agencies.

The National Committee on Urban Transportation in the procedure manual "Standards for Street Facilities and Services" presents a summary of minimum design standards, given in Table 1.

It is not the specific purpose of this paper to discuss freeways and expressways with regard to cross section, but to concentrate more on the urban and suburban problems of major, secondary, and local access-street configuration and cross-section design.

The first six design elements given in this table are pertinent to guide the responsible administrative officials in developing cross-section design requirements. However, the author feels from professional experience in conducting arterial street studies, that there is a need to be more specific in the use of the design elements as they are related to land use and street classification by type. The National Committee on Urban Transportation points out that in using this table a review is necessary to make adjustments to fit the local conditions. In an attempt to be more specific, cross sections have been prepared which correlate the classification of the street on the basis of traffic volume and also its classification regarding the use of the abutting land. Once the land is zoned and the street is classified, the approximate type of traffic composition can be determined and the thickness detail of the cross section decided. As an example, a secondary arterial in an industrial area will be expected to carry a larger percentage of the heavier weight commercial vehicles, and the structural requirement will be more severe. Consistent with this analysis, the pavement thickness has been designed as shown on Figures 2, 3, and 4, with alternates of either asphaltic treatment or Portland cement construction. These cross-section design elements are predicated not only on past professional experience, but also on research information that has been prepared by the University of Washington in Part I, An Equitable Solution to the Problem, of the research report "Allocation of Roads and Street Costs," published in 1956.

Figure 2 gives the minimum street design standards for access streets in outlying or undeveloped areas as well as developed areas, with consideration given to the land use according to its designation as residential, commercial, or industrial. For this paper, these four possibilities of design cross section have been given the classifications of VII, VIII, IX, and X. As can be seen from this figure the surfaced roadway will vary from a 20-foot light bituminous surface-treated roadway for an access street in an undeveloped residential area, to a 36-foot curbed roadway in a commercial or industrial area where additional thickness of the pavement is required to carry heavier wheel loads. For these access streets at least 60 feet of right of way should be provided.

Figure 3 shows the cross-section requirements for secondary arterials in residential, commercial, or industrial areas; the ones classified in this report as Class III, IV, V, and VI. Here, it can be seen that the street surfaced portion varies from 22 feet to 40 feet, depending upon the land use. Right-of-way requirements will range from 60 to 70 feet.

Figure 4 shows the minimum street design standards for major arterials with an average daily traffic exceeding 4000 vehicles, or a four-lane requirement. The Class II street is for all land-use areas—residential, industrial, or commercial—in the outlying or undeveloped areas. The Class I street is indicated as a special situation primarily because more detailed information is needed regarding the design hourly volume. In urban areas the capacity of an arterial is generally controlled by the intersections. The capacity of these intersections is, in turn, related to the vehicle turn movements, percent commercial vehicles, and the signal timing. The cross section shown for this class is purely a suggestion, and additional width should be supplied consistent with increasing traffic-capacity requirements. Detailed capacity considerations are contained in the "Highway Capacity Manual" published in 1950 and revised in 1956. This manual will be completely revised in 1962, and is highly recommended for use in designing arterial street intersections in urban areas.

For the case of major arterials with traffic volume less than 4000 vehicles per day, which would require only two moving traffic lanes, it is recommended that Class III, IV, V, and VI standards for secondary arterials be referred to for cross-section design. However, the pavement thickness should be increased slightly to carry the increased traffic and commercial vehicles.

It should be pointed out that all of the cross sections shown in these figures anticipate that in the developed areas parking at the curb is provided for. There are many locations in hilly urban areas with good views that would require additional construction costs to provide for two moving traffic lanes plus two lanes of parking; therefore the economical alternate might very well be to require the parking to be restricted on one side or both sides.

As should be obvious from what has been presented, traffic-volume requirements are broad enough that right-of-way requirements can be determined without a great deal of difficulty. If the only requirement is to know the demand for right-of-way provisions for future street construction, the decision making is quite simple. However, the details of each individual design for implementing an arterial street network are predicated on sufficient knowledge of the land use and also on the classification of the arterial before the pavement width and thickness can be ascertained. In the report the aim has been to narrow down the decision in a graphical form, as presented in the figures.

TY

NOTES

PROFILE GRADE TO FIT DRAINAGE AND ADJACENT PROPERTY.

PROFILE GRADES WILL NOT NORMALLY BE THE SAME ELEVATION ON BOTH SIDES OF STREET, BUT SHOULD BE ADJUSTED TO FIT PROPERTY AS NEARLY AS POSSIBLE WITHOUT IMPAIRING DRAINAGE.

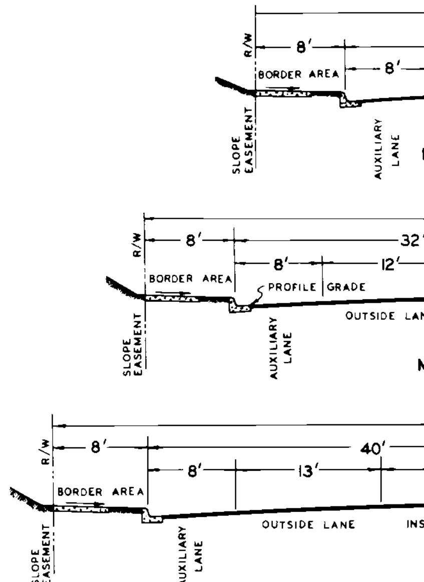
USE PARABOLIC CROWN AT LEAST FOR OUTER QUARTERS, DEPENDING ON CONDITIONS.

MAXIMUM SLOPE AT EDGE OF PAVEMENT TO BE 0.04'/FT.
POSITION OF CROWN VARIES WITH RELATIVE GUTTER ELEVATIONS.

VARY POSITION AND WIDTH OF SIDEWALK TO FIT LOCAL CUSTOM OR ORDINANCE.

SIDEWALKS ARE NOT NECESSARILY INCLUDED IN CONSTRUCTION, BUT GRADING FOR SAME SHOULD NORMALLY BE INCLUDED IN DESIGN WITH PROVISIONS FOR DRAINAGE BACK OF CURBS.

IF ONE-WAY OPERATION IS PROBABLE OR IF PEDESTRIAN VOLUMES ARE HIGH, FURTHER STUDY BY THE TRAFFIC DEPARTMENT WILL BE NECESSARY IN ORDER TO ESTABLISH AN APPROPRIATE STREET SECTION.



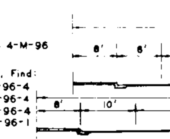
MINIMUM FO

EXAMPLE FOR TR

OBJECT 13' Extra Width available on Type 4-M-96
PROCEDURE:

From Column 13 on Table, Find:

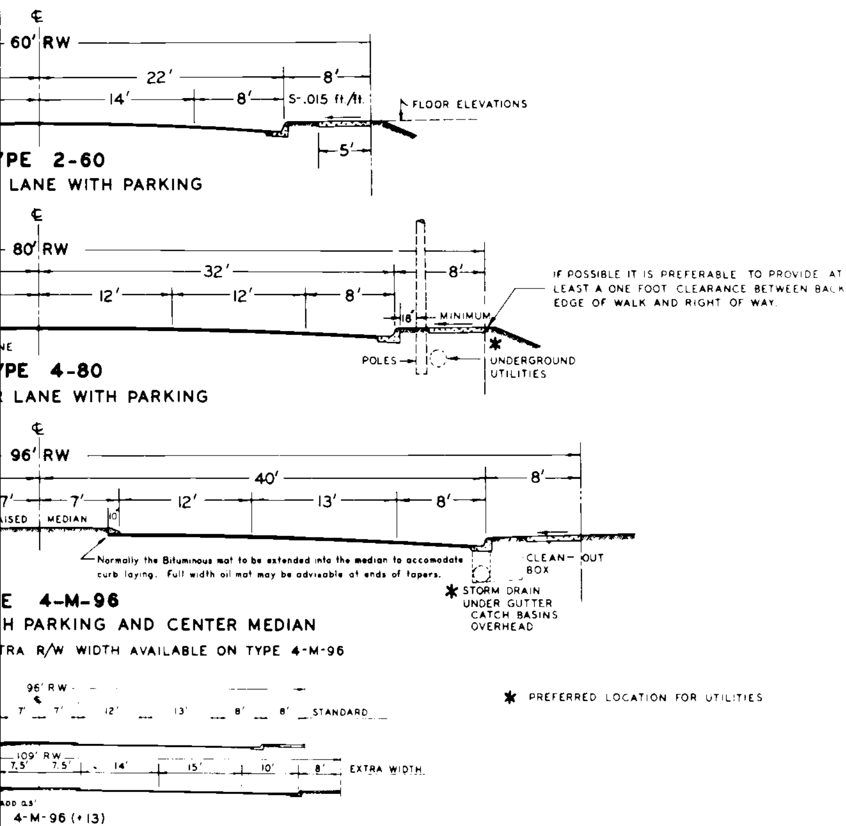
4' Auxiliary Lane	4-M-96-4
4' Outside Lane	4-M-96-4
4' Inside Lane	4-M-96-4
1' Median	4-M-96-1



DISTRIBUTION OF EXTRA R/W WIDTH AVAILAB

ADDITIONAL R/W FEET	1	2	3	4	5	6	7
BORDER							
AUXILIARY LANE							2-60
OUTSIDE LANE	4-80-1 4-M-96-1	4-80-2 4-M-96-2	4-80-3 4-M-96-3	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80 4-M-9
INSIDE LANE	2-60-1	2-60-2	2-60-3	2-60-4	2-60-5 4-80-1 4-M-96-1	2-60-6 4-80-2 4-M-96-2	2-60 4-80 4-M-9
MEDIAN							

RBAN SECTIONS



RD WIDTHS SHOWN ABOVE (USE ½ ON EACH SIDE OF ¢)

0	11	12	13	14	15	16	17	18	19	20
0-2	2-60-3	2-60-4	2-60-5 4-80-1	2-60-6 4-80-2	2-60-7 4-80-3	2-60-8 4-80-4	2-60-9 4-80-5	2-60-10 4-80-6	2-60-11 4-80-7 4-M-96-1	4-M-96-2
0-2 0-2 96-2	2-60-2 4-80-3 4-M-96-3	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	2-60-2 4-80-4 4-M-96-4	4-M-96-4
0-4 96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-80-4 4-M-96-4	4-M-96-4
0-6 0-4 96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	2-60-6 4-80-4 4-M-96-4	4-M-96-4
			4-M-96-1	4-M-96-2	4-M-96-3	4-M-96-4	4-M-96-5	4-M-96-6	4-M-96-6	4-M-96-6

STATE OF IDAHO
DEPARTMENT OF HIGHWAYS

URBAN
STREET SECTIONS

BOISE, IDAHO JUNE 1955

REVISED

APPROVED:
[signature]
STATE HIGHWAY ENGINEER

DRAWING NO. R-23

Table 1

SUMMARY OF MINIMUM DESIGN STANDARDS

Design Elements (All widths in feet)	Expressway	Major Arterial	Collector: Single Family Residential Area	Collector: Other	Local: Single Family Residential Area	Local: Other
Number of Traffic Lanes	4 up	4-6	2	4	2	2-4
Width of Traffic Lanes	12	11	10	11	10	11
Width of Curb Parking Lane or Shoulder	10	10	10	10	8*	10
Width of Border Area	16	12	10	8	10	8
Median Width	20	12	--	--	--	--
Width of Right-of-Way	120 up	100-120	60	80	50-60	60-80
Design Speed	50	40	30	30	25	25
Stopping Sight Distance	350	275	200	200	160	160
Superelevation	.08	.06	.06	.06	.06	.06
Degree of Curve	7.6	11.3	21.0	21.0	--	--
Grade	3	4	8	8	12	12

* Under light traffic conditions, parking may be limited to one side.

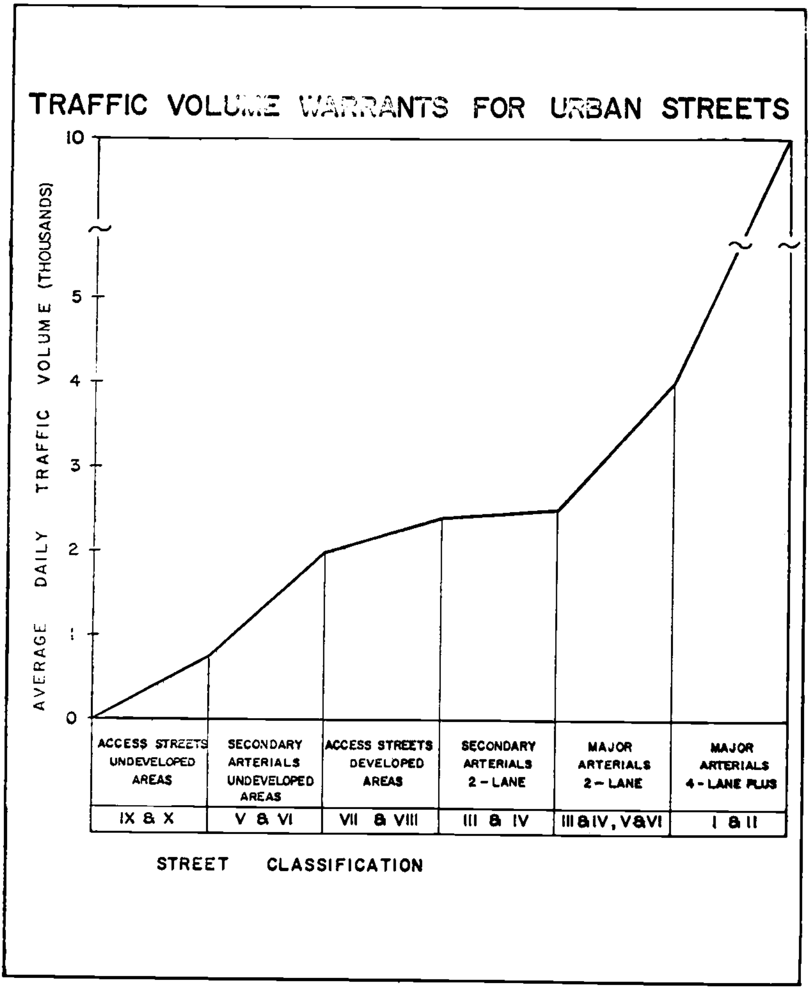
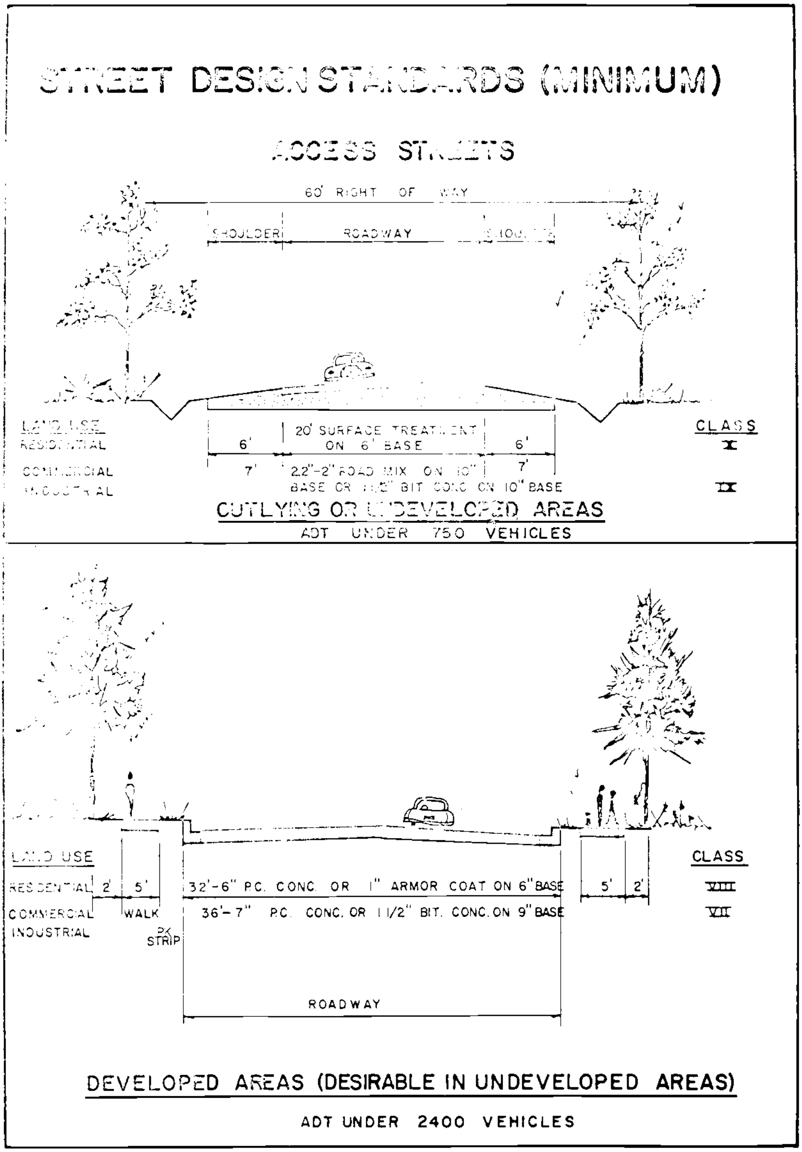

TRAFFIC VOLUME WARRANTS FOR URBAN STREETS
AVERAGE DAILY TRAFFIC VOLUME (THOUSANDS)
10
5
4
3
2
1
0
ACCESS STREETS UNDEVELOPED AREAS
SECONDARY ARTERIALS UNDEVELOPED AREAS
ACCESS STREETS DEVELOPED AREAS
SECONDARY ARTERIALS 2-LANE
MAJOR ARTERIALS 2-LANE
MAJOR ARTERIALS 4-LANE PLUS
IX & X
V & VI
VII & VIII
III & IV
III & IV, V & VI
I & II
STREET CLASSIFICATION

FIGURE I



DESIGN
ACCESS
60' RIGHT OF
ROADWAY
20' SURFACE TREATMENT ON 6' BASE
6'
6'
7'
7'
BIT
10" BASE
CLASS
X
IX
AREAS
ADT UNDER 750 VEHICLES
LAND USE
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
2'
5'
WALK
STRIP
32'-6" P.C. CONC. OR 1" ARMOR COAT ON 6" BASE
36'-7" P.C. CONC. OR 1 1/2" BIT. CONC. ON 9" BASE
5'
2'
CLASS
VIII
VII
ROADWAY
DEVELOPED AREAS (DESIRABLE IN UNDEVELOPED AREAS)
ADT UNDER 2400 VEHICLES

FIGURE 2

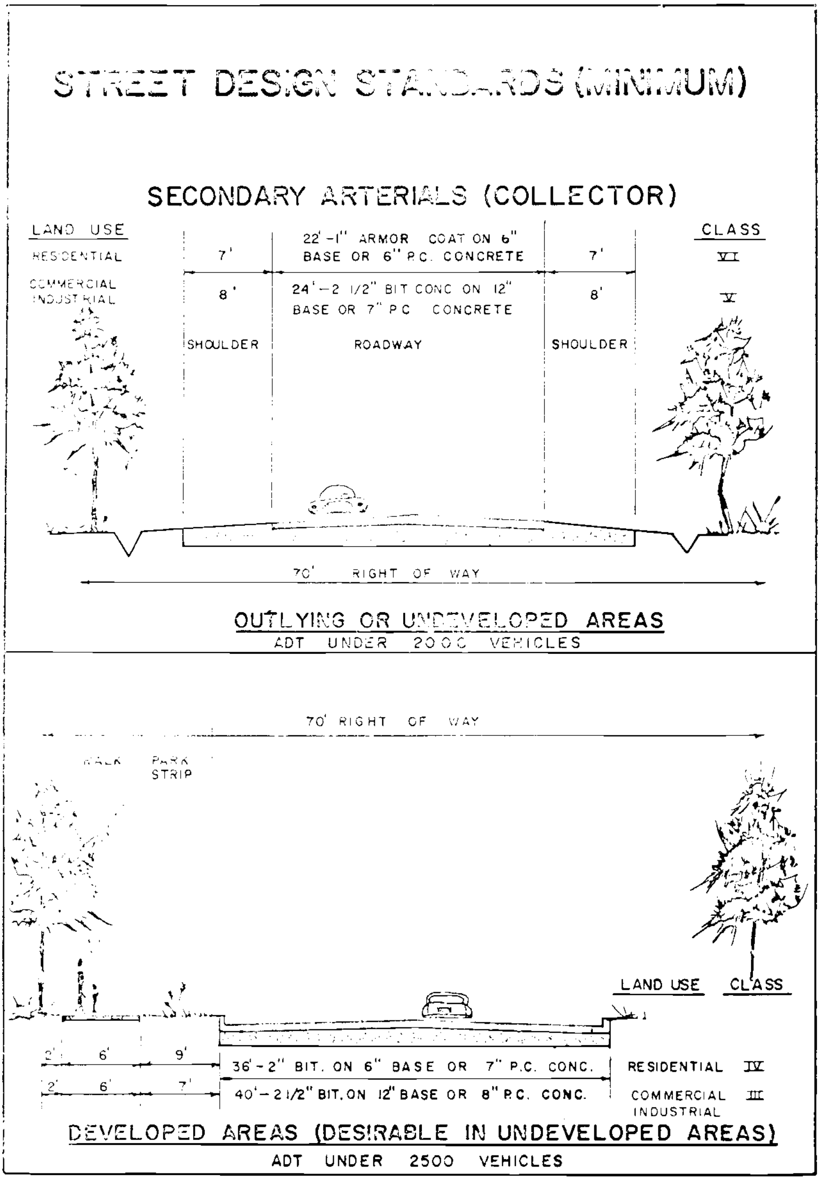

STREET DESIGN STANDARDS (MINIMUM)
SECONDARY ARTERIALS (COLLECTOR)
LAND USE
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
7'
8'
22'-1" ARMOR COAT ON 6" BASE OR 6" P.C. CONCRETE
24'-2 1/2" BIT CONC ON 12" BASE OR 7" P.C. CONCRETE
7'
8'
CLASS
VI
V
SHOULDER
ROADWAY
SHOULDER
70' RIGHT OF WAY
OUTLYING OR UNDEVELOPED AREAS
ADT UNDER 2000 VEHICLES
70' RIGHT OF WAY
WALK
PARK STRIP
LAND USE
CLASS
2'
6'
9'
36'-2" BIT. ON 6" BASE OR 7" P.C. CONC.
RESIDENTIAL IV
2'
6'
7'
40'-2 1/2" BIT. ON 12" BASE OR 8" P.C. CONC.
COMMERCIAL
INDUSTRIAL III
DEVELOPED AREAS (DESIRABLE IN UNDEVELOPED AREAS)
ADT UNDER 2500 VEHICLES

FIGURE 3

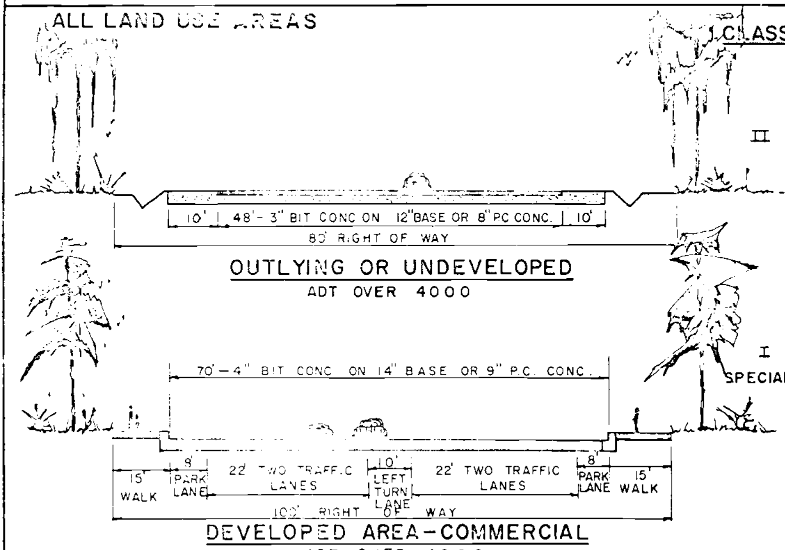
STREET DESIGN STANDARDS

(MINIMUM)

MAJOR ARTERIALS

(INCLUDES STATE HIGHWAYS WITHOUT ACCESS CONTROL)

	CLASS
FOR ADT UNDER 4000 VEHICLES	VI
USE SECONDARY ARTERIAL STANDARDS	V
	IV
AND PROVIDE 80' MINIMUM RIGHT OF WAY	III



• THE ROADWAY CROSS-SECTION FOR THESE STREETS ARE PREDICATED ON THE BASIS OF THE DESIGN HOURLY VOLUME AND INTERSECTION CAPACITY, WHICH IS A FUNCTION OF PARKING PROVISIONS TURNING MOVEMENTS, COMMERCIAL VEHICLES, AND SIGNAL TIMING.

FIGURE 4

URBAN-SUBURBAN STREET IMPROVEMENT STANDARDS

Access Control for City and County Arterials

Norman Kennedy and Wolfgang S. Homburger

Historically, streets have served the dual function of providing access to adjacent land and of moving traffic along their routes. When all traffic moved at the speed of man or beast, it mattered little to through traffic if an oxcart pulled out of a wheatfield or a citizen stepped out of his doorway directly into the street. The speed and volume characteristics of today's through traffic, however, have introduced a basic conflict between the two groups of users that results in some degree of hazard and inconvenience for each.

In recent years we have tried to separate these conflicting functions by designating and designing different roads with varying emphasis on the movement and access roles of each. Access control is a major feature of the design for streets intended primarily for through movement. Figure 1 shows schematically the principal road classifications. At one extreme, the cul-de-sac provides unrestricted land access but no service for through traffic; at the other, the freeway provides a high standard of service for traffic movement but no direct land access. Between these two extremes other highway types offer varying levels of service to through movement and to land access.

The extent to which access should be controlled at the two extremes of street classification is easily settled. For any street or highway falling between these, basic questions need to be answered. Which function is really predominant? How much more predominant is it? What is required in the way of restraint on the secondary function to insure that the predominant function can be performed in accordance with some agreed standards? The answers to such questions will determine the classification of the highway and the way in which it should be designed and operated.

If it is decided that the land access function is vastly less important than the movement function, the facility is classified as an expressway or freeway. In such facilities, the basic components are designed entirely for through traffic. Adjacent land is provided access from separated local streets, which may be either immediately adjacent to the expressway—in which case they are referred to as frontage roads—or may serve abutting lands from the side or rear.

Where the design includes frontage roads, the land access from abutting property is not materially changed, but the separator between the frontage road and the expressway eliminates interference of access maneuvers from through traffic. This method of access control can be used on full freeways, expressways with some at-grade intersections, and even on wide city streets, divided longitudinally into a center roadway and two outer roadways.

Where frontage roads are not to be provided, it is generally necessary to purchase the access rights of adjacent land owners, as well as supplying them with alternate access routes.

Arterials

Arterials are generally defined as being intended primarily for through traffic; serving abutting land only secondarily. Access to abutting lands is not completely denied, however, (if it is, the street is classified as an expressway or freeway) and therefore the nature of the access needs to be characterized before deciding whether or not to control it.

Access functions of streets include:*

1. Pedestrian access to and from abutting land.

2. Vehicle access to and from abutting land, using driveways or other connecting vehicular paths.

3. Access by occupants of vehicles to abutting land, leaving the vehicle parked in the street.

4. Access by passengers of vehicles to abutting land, with the vehicle continuing on its trip.

5. Access of goods carried to and from abutting land, with the vehicle stopped in the street during the loading process.

*A related aspect is the provision of access between intersecting highways. This type of access does not fit neatly into a schematic diagram. True, in a freeway access to most intersecting streets is eliminated, and to the remaining—major—streets is by means of interchanges. But access to intersecting streets from local streets may also be kept to a minimum. This, in fact, is found commonly in modern subdivisions laid out with superblocks and cul-de-sacs, and having relatively few street intersections.

The access function in a street is performed by one or more of the following features:

1. Pedestrian sidewalks.
2. Driveways into the street.
3. Parking spaces at the curb.
4. Passenger loading spaces at the curb.
5. Truck loading spaces at the curb.

Highways designed to perform no access function (i.e., freeways) contain none of the features just enumerated and, indeed, usually are fenced at the right-of-way lines to prevent unauthorized use of the facility for land access. Other classes of highways may have some or all of these access features in varying amounts or degrees of development.

Methods of Access Control

1. Pedestrian access: On arterials, pedestrian access to abutting land is not eliminated. However, it may be de-emphasized (and movement functions correspondingly enhanced) by reducing the width of sidewalks.

2. Vehicle access: On most arterials, vehicle access to abutting land is not eliminated, but points of access (curb cuts and driveways), especially near intersections, are usually regulated by ordinance. Vehicle access can be reduced to some degree if lots on corners are provided with access to side streets rather than the arterial. Complete elimination of curb cuts and driveways is possible if alleys are furnished paralleling the arterial at the backs of the abutting properties.

3. Access of vehicle occupants: Access to adjacent property by vehicle occupants, when the vehicle itself is parked within the street, is often reduced or eliminated on arterials.

a) Selective access restriction is effected by limited curb parking regulations. Time-limited parking zones deny access to all-day users of abutting properties. Peak period parking prohibitions eliminate access for vehicle occupants wishing to be on abutting property during such hours. Loading zones eliminate occupants of private automobiles from using particular curb space for access.

b) Complete elimination may be effected by permanent "No Parking" regulations.

c) Greater emphasis on access is sometimes achieved by allowing angle parking at the cost of reducing the movement function on streets. However, this can only be allowed on the widest arterials, where ample road space remains for through movement.

4. Access by vehicle passengers: Access by vehicle passengers, when the vehicle continues on its trip, requires some curb space for unloading and loading. Such access may be enhanced by establishment of passenger loading zones for buses and/or automobiles. It is also provided when parking is prohibited, but stopping is allowed.

5. Access for goods carried by vehicles: Goods may be transferred to and from abutting land while the vehicle itself remains in the street during the trans-shipment process. Such access can be enhanced—at the cost of other forms of access—by establishment of loading zones. It can be reduced or eliminated by regulations governing such vehicles. Zoning regulations may require off-street loading docks in commercial buildings so that the loading function may be removed from the arterial, or, indeed, from any class of street.

Benefits to the Movement Function

1. Pedestrian access control: De-emphasis of pedestrian access functions through the narrowing of sidewalks provides more roadway width, and hence more capacity for movement of vehicles in the roadway.

2. Vehicle access control: Every curb cut and driveway is a point of potential conflict to through traffic. Control of vehicle access will reduce or eliminate these points of disturbance and improve the operation of the affected traffic lanes.

3. Access by vehicle occupants: Time-limit curb parking restrictions have, sad to say, no beneficial effects on traffic flow. In fact, an increase in parking turnover means an increase in parking maneuvers and a corresponding increase in the conflicts presented to through traffic. However, complete parking prohibitions during certain hours or permanently making additional street width available for moving traffic will enhance the movement function of the arterial.

4. Access by vehicle passengers: Control over passenger loading zones permits their location at those points which will tend least to disrupt moving traffic. Complete elimination of passenger access—"No Stopping" regulations—will assure smooth flow for moving traffic in the curb lane.

5. Access for goods: Control over truck loading zones similarly permits their location at suitable points and, in addition, tends to reduce double parking by trucks. Absence of suitable loading zones may, in fact, bring the traffic lane adjacent to the curb lane to a halt every time a truck double parks.

Degree of Access Control Required

The degree of access control required will depend on the level of movement service to be furnished. The NaCUT (National Committee on Urban Transportation, "Standards for Street Facilities and Services," Chicago: Public Administration Service, 1958. Procedure Manual 7A) has proposed certain standards for arterials and for the level of service which they should offer. Design of an arterial should permit such a level of service to be available to the anticipated volume of through traffic. After such accommodation has been made, the remaining street capacity can be developed for access uses. However, it may never be possible to provide all the desired amenities to through traffic if the facility is to remain in the arterial category.

It would seem presumptuous, not to say difficult, to set forth a table of standards. More appropriate might be a suggestion that the analysis of an arterial include the following steps:

1. Comparison of geometric dimensions with the standards of the National Committee.

2. Comparison of overall speeds on arterials with the standards of the NaCUT—25 mph in peak hours and 25-35 mph in off-peak hours.

3. Comparison of accident rates with the maximum levels which NaCUT feels can be achieved.

If the arterial falls short on any of the above comparisons, the various methods of improving through movement at the expense of accessibility to adjacent land may have to be used singly or in combination. In addition to estimating the degree of improvement to the level of service for through traffic, each alternative must be evaluated from the point of view of cost, effect on the adjacent land, and political implications. It must be recognized that certain types of land use are more dependent on maximum accessibility from adjacent streets than others, and that access de-emphasis might be unacceptable in such areas.

Consideration might even have to be given to shifting the arterial status to another street if the land access function on the present arterial cannot possibly be reduced.

We must continually remind ourselves that final decisions will be made by the city or county governing body. The engineer and planner must clarify the issues to his board in terms of the conflicting needs which an arterial attempts to meet. They must show the degree to which both traffic movement and land access can be met in alternative solutions. They should recommend the optimum development for the arterial and be prepared to justify their choice in the arguments on movement versus access which are sure to follow.

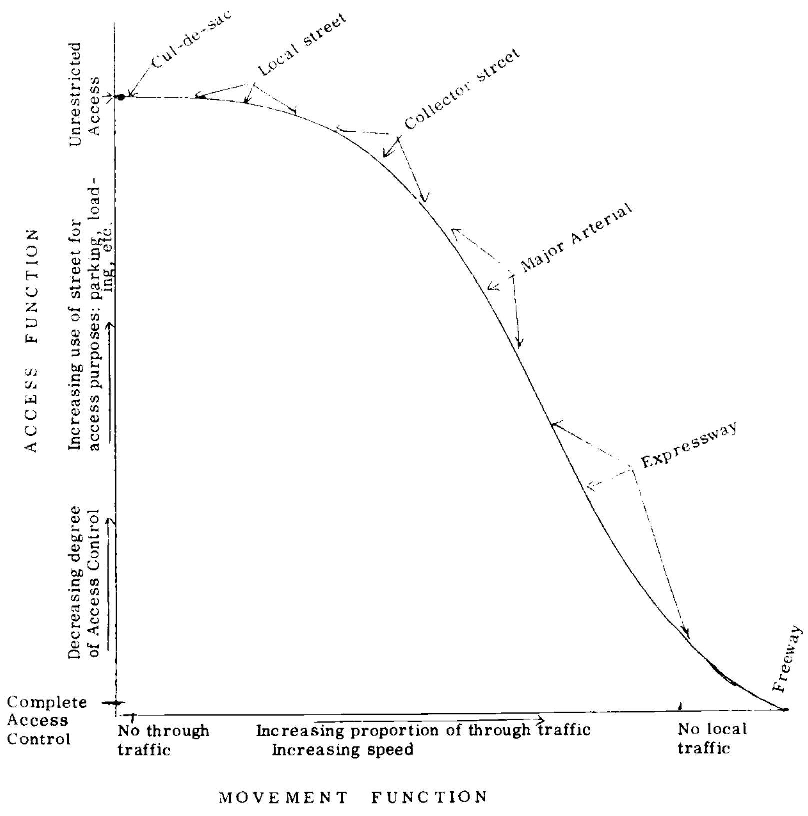


Fig. 1 — Schematic classification of streets by function.

COORDINATING URBAN TRANSPORTATION STUDIES
The Engineering Concept

R. C. Blensly

Historical

Development and growth of American cities during the latter part of the Nineteenth Century and the early part of the Twentieth Century were influenced by the modes of transportation consisting of street-railway systems, horse-drawn vehicles, bicycles, and pedestrians. These relatively slow and limited modes of transportation resulted in a concentration of business and retail outlets in a central area, commonly called the "Central Business District" (CBD). Inasmuch as the majority of the movement of persons in an urban area was from home to work, there was a necessity of providing as short a distance between these two areas as possible. This resulted in the development of multifamily housing adjacent to the central business district. The families with more financial independence and the ability to provide horse-drawn vehicles of transportation lived on the fringe of the residential development in single-family dwelling units.

Those areas which were served by railway or streetcar lines experienced considerable residential development. The basic gridiron pattern of city streets, which was developed during this period, was adopted to facilitate land subdivision and to provide access to private property, with very little consideration given to providing for movement of goods and persons in a large number of individual vehicles.

The development in the Twentieth Century of a mode of transportation usable by the individual and capable of providing travel for relatively long distances in short periods of time has had a pronounced effect on the development of urban areas. The private automobile has made it possible for individual families to move relatively easily and with little regard for the distance and direction required to travel. The relatively high average income has made it possible for most families to own at least one automobile. Use of this automobile has allowed more and more families to live in single-family dwelling units and not have to worry about the problem of walking or using mass transit to move from their homes to places of employment, shopping, or recreation.

Urbanization

Use of the automobile for transportation in the past decade has been accompanied by a shift of population from the rural to the urban area. Increasing efficiency of the methods and equipment used for farming has reduced the need for the number of people remaining on farms. Increased standard of living of the American people has increased the need for personnel working in the services of manufacturing industries. These technological changes have brought about a natural shift of population from rural to urban areas.

Introduction of the automobile as a more flexible and convenient method of transportation for the individual, resulted in a sprawl-development of single-family dwelling units. During recent years, a large portion of this expansion has been in the suburban fringe areas adjacent to incorporated cities. To provide services for this suburban population, many retail establishments for consumer goods have established suburban shopping centers near the concentration of residential homes. Although some businesses have been removed from the central business district, it still provides many services and goods which are not available in outlying shopping areas. The central business district remains as a definite focal point for a large number of trips made in an urban area.

Improved methods of transportation have had their influence on commercial and industrial expansion, as well as residential development. Commercial and industrial expansion is now dependent to a large extent on the availability of highways, roads, and streets, with only few dependent on railways.

The resulting changes in the development of urban areas and methods of providing transportation for persons and goods have resulted in some very serious problems. The mass transit industry has been losing patrons quite steadily to the more flexible private automobile. The use of mass transit normally is less attractive than the use of private automobiles because its users must conform to fixed routes and schedules, and do not have the independence and flexibility of operation which the American people desire.

The present average income for families is of sufficient amount that it is not financially necessary for large portions of our population to use mass transit. The dispersing of our shopping areas from the central business districts to suburban shopping centers has made access much easier. The convenience of the private passenger car and the relatively short distances required to travel to the shopping centers, has resulted in a large number of vehicle trips. The result of these changes in urban development and transportation vehicles has been congestion on the streets and a lack of parking facilities at the terminals of these trips.

Transportation Planning

The past development of our urban areas has not been based on a coordinated and well planned program. In most cities the areas within the incorporated limits have been subject to some control with respect to subdivision of land and development of transportation facilities. However, the growth of urban areas has been largely outside of the incorporated limits in areas for which there has been practically no control for subdividing lands or the provision of adequate allowances for future transportation needs. The lack of coordination in the development of urban areas has created many transportation problems which must be resolved if the community is to provide the facilities and services which the general public has come to desire.

Development of an adequate transportation system for an urban area requires the combined efforts of all political jurisdictions and public employees involved in the development of public improvements to obtain, analyze, and integrate the factual data which will provide the basis for the development of a transportation system.

The engineer in the past has been primarily concerned with the economics of locating a vehicular roadway, and he has not been prone to give adequate consideration to the effects upon the location of a roadway to items such as the subdivision of homogeneous areas—construction of barriers denying access to schools, churches, hospitals, and other community areas; the most desirable form of land use—and many other problems which face the local officials in an urban area.

The trend in the past few years of decentralization in the urban areas and the increased mobility of the general public resulting from the increased use of private automobiles has resulted in severe congestion, delays, and increased accidents on most of the arterial streets in the urban areas. To reduce the congestion, delays, and high accident potential, new facilities have been provided to move the long-haul traffic in such a manner that it is insulated from as much other traffic as possible. These improved facilities are being constructed with access control that prohibits promiscuous crossings and service to abutting property.

Provision of access control facilities has brought increasing problems to the urbanized areas. To overcome these additional deficiencies, engineers have recognized a need for the coordinated development of the transportation system with other functions provided in an urban area. This correlation of planning requires the combined and united efforts of construction engineers, traffic engineers, urban planners, and public transit operators and other civic officials to develop a transportation plan which will recognize all of the urban problems and coordinate these problems to provide a transportation system which will better serve the general public by maintaining the continuity of urban development and still provide transportation with a minimum of congestion and delay.

In recognition of this need for coordination, there was established in recent years a National Committee on Urban Transportation. This committee has developed an outline of procedures necessary to assist in the development of a coordinated transportation system. The general guide, "Better Transportation for Your City," outlines the general procedures which should be followed in the development of transportation planning. Supplementing this publication is a series of procedure guides to be used by technical personnel in collecting and developing the data necessary for the orderly planning of a transportation system.

Experience in any urban area indicates that the successful transportation planning can be developed best in six orderly steps or stages, which may be briefly listed as follows:

Stage I, Organizing for the Job
Stage II, Getting the Transportation Facts
Stage III, Defining the Problem
Stage IV, Developing the Transportation Plan and Financial Program
Stage V, Adopting the Preferred Plan and Financial Program
Stage VI, Carrying out the Plan

The stages outlined for the development of a transportation system require an organization to develop coordination among the many jurisdictional agencies normally involved in an urbanized area. The National Committee outlined an organization that implies a single political jurisdiction for the major portion of the study area. Therefore, they recommend the appointment of a program director to supervise the program, and a technical coordinating committee composed of key officials of municipal departments and other agencies to assist and advise the director.

The urban areas in Oregon generally consist of several political subdivisions, and therefore no one agency has assumed the responsibility for urban planning. The organization for studies in Oregon has vested the program supervision in a coordinating committee consisting of representatives from each of the political jurisdictions. Each representative has been a policy making member of his agency. In many instances, the members are the political heads of their jurisdiction.

A Technical Advisory Committee whose membership consists of technical personnel familiar with the procedures to be employed in planning and executing the study has been established to supplement and assist the Coordinating Committee. The Technical Advisory Committee membership normally consists of the individuals who head up the fact finding projects for the program.

Experience in Oregon has indicated that this form of organization has been successful in developing coordination for the planning of the transportation system. Timing for developing the Coordinating Committee and the Technical Advisory Committee, however, has not been the same for all the studies conducted in Oregon. For the Portland-Vancouver metropolitan area, the need arose for obtaining the factual data necessary to develop the transportation plan in such a manner that it was imperative that the preliminary planning for collection of factual data be completed before an official coordinating committee was established. Inasmuch as the procedures necessary for collecting the factual data were well under way at the time the coordinating committee was established, an immediate need was not recognized for the appointment of a Technical Advisory Committee. Problems did develop, however, which indicated that the establishment of the Technical Advisory Committee would improve liaison among the various organizational units responsible for development of the factual data.

Planning was completed for the Salem area on an informal basis by a group of officials who would normally be charged with responsibility of fact gathering for the development of the transportation system. Upon completion of the preliminary planning, a suggested approach was presented to an existing organization, the Inter-Governmental Cooperation Council, for consideration. This group consisted of the political heads of the jurisdictions in the urban area. With some minor modifications, the Inter-Governmental Cooperation Council accepted the responsibility as the Coordinating Committee, and appointed the study group as a Technical Advisory Committee.

In the Eugene area, the Coordinating Committee and the Technical Advisory Committee were created at approximately the same time, and major responsibilities for preliminary planning, development of the procedures, and the collection of factual data were assigned to the Technical Advisory Committee by the Coordinating Committee.

Assembly of a technical staff to perform the physical acts of gathering and analyzing the factual data desired has taken several different forms. One of the most popular for larger metropolitan areas has been the establishment of a project staff under the supervision of a full-time director. This type of organization requires a financial contribution of each participating agency based on a predetermined allocation of cost. The project director normally reports directly to one of the major participating agencies. The working personnel for this type of organization may be transferred from other duties or employed specifically for the project. The latter course requires hiring key personnel with a very high level of ability and specialized experience, with no guarantee of long-range employment.

Another way of handling the problem is to recognize the abilities and responsibilities of each of the participating agencies and assigning to them those portions of the overall study for which they have personnel with the proper training and background, or where it is more convenient, to work locally and to coordinate work performed by individual agencies through the Technical Advisory Committee. Organizations of this type present some coordination problems, however, although this has not been an obstacle to date in any of the studies conducted in Oregon. The Technical Advisory Committee, consisting of technical personnel from participating agencies, evaluates the abilities of each of the participating agencies to develop a recommended division of responsibility for participation in the various stages of development of the transportation plan. The recommendations of the Technical Committee can be presented to the Coordinating Committee, which normally consists of the policy making members of the participating agencies, and therefore can be approved with assurance that each participating agency will follow through on its assigned responsibility.

In conclusion, it has been recognized that the needs of an urban area are so complex and inter-related that no one single agency is normally in a position to coordinate all activities or to integrate all of the urban needs in the development of a transportation system which will provide adequate transportation for the present and for the future. Therefore, all agencies having the responsibility for the development of public service facilities in an urban area must join together to provide a well integrated and coordinated urban transportation system.

The engineer many times is confronted with an extremely difficult problem. He recognizes that he must be a part of the team to develop a coordinated transportation system. He further realizes that the roadway facilities which he constructs have a definite result on the development of the community and the development of other public service facilities. In spite of these recognitions, however, he is often confronted with financial limitations which preclude providing all roadway facilities in accordance with the most ideal conditions as envisioned for the transportation system.

He must, therefore, based upon his judgment and evaluation of the supporting data used in developing a transportation system, provide transportation facilities integrated with other community activities to the extent possible and still remain within the financial means. This many times results in a rather simple down-to-earth location and design and the elimination of some of the grandiose appurtenances felt desirable to provide the finishing touches and aesthetic values desired within an urbanized area.

TRAFFIC SAFETY
Accident Records

David W. Schoppert

Engineers use accident records for a variety of reasons and in a variety of ways, but all of these relate back to a very simple fundamental. The purpose of our efforts is to build and operate a road and street system which gives the people safe, convenient, economical transportation. The test of our efforts, then, is the degree of safety, economy, and convenience which the people enjoy. Of those three general measures, only one—safety—can be measured directly. So, we collect and analyze accident records. In actual practice we use them in four general ways:

1. To help develop improvement programs.

2. To help sell the program.

3. To help prove the effectiveness of past work.

4. To help focus enforcement and educational programs on questions of interest to us.

Now, let us look at those four a little more specifically. In developing a program we begin by locating those sections on the system where accidents are occurring, then by studying the accidents to determine what might be done to reduce these. We use norms of one kind or another to compare each section, we do research to devise and test ways of reducing accidents, and we use spot maps or tabulations to locate the bad sections.

The kinds of improvement vary from entire new concepts of design—for example, the principle of freeways—to such mundane and seemingly insignificant things as cutting brush or moving signs.

The cumulative effect of engineering measures is really very dramatic, and engineers can take real pride in the significant and lasting contributions they have made to traffic safety over the years.

Once an improvement or a program is developed, it must be sold. I use "sold" here to include both administrative and public approval. In this regard accident records can be of infinite value. They show, as few other facts can, the value of improvements, the reasons for the type which was chosen, etc.

This includes not only physical improvements like widening, realignment, and resurfacing, but operational improvements as well, such as one-way streets, turning prohibitions, channelization, signing, etc.

It is surprising how extensively accident records can be used. In one state it was noted recently that certain areas had nearly all of the skidding accidents. In the course of trying to discover why, it was found that in the areas with many skidding accidents the aggregates used in paving were different from those used in other areas. Testing of these aggregates under different conditions showed that although they passed the construction specifications with flying colors, they polished after a period of time and a few weather cycles to the point where they were dangerously slick. The odd thing was that they were not apparently slick, and this situation had gone unnoticed for many years. Specifications for paving aggregates have since been changed, and skidding accidents are on the decline.

This is just one example, there are innumerable others dealing with every engineering function from planning and design through construction and maintenance.

We also use accident records to prove (or disprove) the effectiveness of things we have. We knew that freeways would be safer than conventional roads and streets, but I doubt if many of us foresaw just how much safer. It was not until we had experience with them that the "doubting Thomases" were satisfied. To progress we constantly have to learn from our successes and our failures. In a profession known for a factual bias, the old saying, "Well, we haven't had any complaints," just will not cut the mustard. We insist on knowing how much better or how much worse, and accident records tell us.

The great strides in safety over the years have come from adopting the good and discarding the bad. Accident records have frequently been the deciding factors. Let us face it—it costs as much, sometimes more, to build a bad highway. Economy is not always a clear indicator of the desired practice. An unsafe highway may be just as convenient as a safe one, so convenience does not always give the answer. However, we frequently can build in safety at no extra cost and no sacrifice in convenience. We have learned, and can show the scars to prove it, that regardless of how good a highway looks, if it isn't safe it will stand there belittled and detested by the public, a discredit to our profession and a haunting reminder of poor use of public funds.

Lastly, we recognize that our profession does not have all the answers, that education and enforcement can be effective partners with engineering in wringing the last ounce of safety out of our road and street systems. So, we use accident records to show us how to focus these on our problems and to help us explain to our friends in enforcement and education what we want and why we want it.

For example, we have worked with both educators and enforcement officers to help the traveling public adjust to the different demands of freeway driving. A few engineers are reversing this and using police arrest records to help them locate places where the public is getting into trouble, on the logical assumption that places where many arrests are occurring might have basic faults in signing or other subjects of engineering concern.

Engineers do all of these things I have briefly discussed, but not all engineers do them. This is a point of concern to all of us. Accident records are exclusively for the use of highway departments and large cities. They can be helpful to anyone with road or street responsibilities. Moreover, the techniques for using them are simple—mostly just common sense. Any city or any county can have good accident records at very little cost. If you are not using them, you should be.

Remember, these can help you:

1. Develop improvement programs.

2. Sell your improvement program.

3. Prove the effectiveness of just work and therefrom improve in the future.

4. Focus enforcement and educational programs on your problems.

I have listed below certain publications which are helpful, and all state highway departments will help the cities and counties to get the records and put them to productive use.

Procedure Manual 3E of the National Committee on Urban Transportation describes a procedure for maintaining accident records. It was prepared by the National Committee on Urban Transportation and published by the Public Administration Service.

It is available from the publisher for $1.50. Write Public Administration Service, 1313 E. 60th Street, Chicago 37, Illinois.

Other good sources of information are National Safety Council's Public Safety Memos Nos. 40, 69, and 75.

For accident investigations by the police, there are several sources, one of the best is the Traffic Accident Investigator's Manual for Police, published by the Traffic Institute of Northwestern University.

For engineering studies of high accident locations, the Manual of Traffic Engineering Studies is a good source. It is available from the Institute of Traffic Engineers.

TRAFFIC SAFETY

Auto Crash Injury Research - Some Further Thoughts

Max deNovellis

In the field of traffic safety there are two approaches to the problem of how to reduce the frequency and risk of death and injuries due to the automobile accident.

The first approach is concerned with prevention; keeping the accident from occurring in the first place. The difficulty in this approach is that we still know all too little about what causes accidents, so that whatever preventive measures that may be adopted and implemented in all good faith are still in the hit and miss class, with little or no way to measure their effectiveness.

To compound this dilemma, we have an ever increasing car population which is rapidly outstripping police enforcement and road engineering efforts to keep up with it. Experts tell us that in the next decade or two, to keep pace with the expected large increase in vehicle mileage, we shall have to reduce the accident rate by nearly 50 percent from what it is now in order even just to stand still.

The second approach to injury prevention is less widely known, having come into prominence only within the past half dozen years or so, but it is one which holds a good deal of promise in helping to reduce the highway death and injury toll. Predicated on the possibility that accidents may continue to occur despite the best of prevention activities, Cornell University set out to find the causes of impact trauma. The collection of accidents on a mass basis, through a cooperative team effort involving state medical, public health, and law enforcement groups throughout the United States, has afforded Cornell the opportunity to scrutinize the data by mathematical means in order to recognize common injury patterns, as related to the interior design of the automobile, and their obvious variables. These data, on analysis, are being used as guides by the automotive industry in the development of devices to protect auto occupants from the forces involved in an automobile crash.

Through this team effort, various aspects of the crash injury problem have been under investigation. Among them are a study of automobile doors opening under crash conditions; ejection and automobile fatalities, a report on safety belt effectiveness; an evaluation of door lock effectiveness; child injuries in automobile accidents; and a study of speed in injury-producing accidents.

In this paper I would like to deal with some of the more recent findings as related first to door lock effectiveness and the ejection factor; secondly, the seat belt syndrome; and, finally, speed as related to accident configuration.

Perhaps in no other area of automotive safety has a more important contribution been made than the development of better door locks which came on the market with the introduction of the 1956 car model. A brief review of some of the earlier findings by ACIR, beginning back in 1957, will be undertaken. This was when the concept of being "thrown clear" of an auto when an accident occurred was shown to be the exception rather than the rule. It was found that ejection was a frequent and hazardous event when doors opened under impact conditions, and that the differences in the risk of fatality was five times greater for ejectees than for those who stayed inside the car.

Later ACIR studies were concerned with two ways to prevent ejection. One was the seat belt. The effectiveness of this simple device had been demonstrated in a very early crash injury study of aircraft accidents, but it was not until 1956 that ACIR, in an analysis of a small sample of seat belt cases, indicated that a substantial reduction of dangerous and fatal injuries could be accomplished with increased seat belt usage. It was from a larger and more cohesive sample collected in California that ACIR was able to examine the effectiveness of seat belts. In this study, done in 1960, we found that the use of seat belts reduced major and fatal injuries by about 35 percent, and that possibly two-thirds of this reduction resulted from the control of occupant ejection.

Another way of keeping people inside the car is, of course, to keep the doors closed. Beginning with the 1956 car model, when car doors were modified to curb occupant ejection, it was felt that this type of safety engineering had an advantage over the employment of seat belts in that it required no unusual action on the part of the occupant.

The true test of the effectiveness of new door locks was yet to be undertaken and could only come from actual crashes on the highways. A study of post-1955 automobiles with modified door locks as compared with older model cars in order to determine the effectiveness of the new locks was undertaken by

ACIR. This paper dealt with a comparison of pre-1956 cars with post-1955 cars under similar conditions of highest impact speed (in the accident), principal area of impact and body style, in order to determine if the frequency of one or more front doors opening, of occupant ejection, and of dangerous or fatal injury, had changed. Some of the principal findings will be discussed in this paper.

With a growing public awareness of the fact that better door locks and increased seat belt usage could protect car occupants in case an accident occurs, ACIR has gone on to study seat belt usage to determine whether there is a possibility that the introduction of belts might increase the frequency or severity of certain injuries—particularly those in the abdominal region. From the medical point of view, it is well known that in any prophylactic or therapeutic regimen, the introduction of a new variable usually leads to a modification of a clinical picture. Just as the use of penicillin has led to numerous examples of penicillin allergy or anaphylactic reactions, so in the use of seat belts many physicians and investigators feared that the belt itself might contribute to many untoward situations and injuries. In brief, it was suspected that a "seat belt syndrome" might appear.

Review of available data in the literature, particularly with reference to the injury effects of belts in automobile accidents, indicated the need for further study in order to determine the relationship between seat belts and abdominal or other lower torso injuries. In an effort to provide this information and to determine whether such factors as accident conditions, belt failure, or occupants physical characteristics were associated with seat belt caused injuries, a study was undertaken.

The principal aim of this study was to determine whether seat belts were a direct cause of injury. Consequently, the study is limited to abdomen-pelvis and lumbar spine injuries, and no effort was made to determine the effect of the seat belt on overall injury patterns. Two topics were covered:

1. Data concerning seat belt users who sustained lower torso injuries were selected and categorized according to injury type and severity. Accident circumstances were then examined in order to determine the relationship, if any, between various accident factors and injury.

2. Cases in which occupants' belts failed were examined

because the failure of a belt presumably indicates a level of force which could conceivably produce abdominal or other lower torso injuries. Information regarding failure types as well as belt type (cam or metal-to-metal) was also recorded where possible.

A third topic, the relationship of age, weight, height, and sex of belt users and the frequency of lower torso injury or belt failure was also explored.

Perhaps one of the most controversial of automotive safety subjects is concerned with the role of speed in the crash injury picture. Common assumption is that fatal injuries are associated with high speed, and that if speed were rigidly controlled, fatal crash injury could be eliminated.

An earlier study conducted by Cornell explored the relationship between speed and injury or death. It was shown that in injury-producing accidents there was a statistically significant association between increases in both traveling speed and impact speed and the frequency of dangerous or fatal injury.

In each of the 10 mph traveling speed ranges through 59 mph, the increases in frequency of dangerous or fatal injury were slight; beyond 59 mph the increases rose sharply. Among the occupants of cars traveling above 59 mph (represented by 25 percent of the cars observed), the frequency of dangerous or fatal injuries was nearly three times as great as it was among the car occupants traveling below 59 mph. Yet, it was shown that complete and absolutely controlled top speed limits would afford relatively limited reduction in the expectancy of dangerous or fatal injuries in injury-producing accidents. Strict maintenance of a top traveling speed of 49 mph would still have seen the occurrence of 60 percent of the dangerous or fatal injuries.

Many factors other than speed operated to produce injury in automobile accidents. Acting independently, interdependently, or together with speed were such accident factors as ejection, seat area occupied, and site of crash impact.

In the bulk of injury-producing accidents, dangerous or fatal injury in low-speed ranges, except where ejection occurred, appeared to be very largely a function of the shape and form of interior car components—whether these were struck, and what parts of the human body struck them—and such injuries in the higher speed ranges apparently associated with an interacting combination of both the dynamic results of speed and the design of the car.

Speed regulation without simultaneous control of car design imposes limitation on the extent of reduction of dangerous or fatal injuries in injury-producing automobile accidents. Aside from being a key factor in influencing the frequency and severity of injury when accidents occur, speed requires further study in order to place its influence in proper perspective with relation to other accident-injury factors.

Among the topics to be discussed in the studies of speed are:

1. Influence of speed on frequency and severity of injury with due regard to such factors as accident configurations, seated position, and occupant characteristics.

2. Threshold of injury, the lowest speeds at which injuries occur and the upper limits beyond which it is most probably not practical to control injury through design engineering.

3. "Expectancies" of varying degrees and types of injury under hypothetically controlled speed ceilings.

TRAFFIC SAFETY
The Challenge of Coordination

Warne Nunn

There is a common bond which has brought us together today. That bond is a job responsibility and a deep personal interest for the safe, smooth, and economical movement of motor vehicles.

To be sure, our perspectives may differ as we each look at the problem of how to achieve the ideal in movement of motor vehicles, but I believe we all are aware of the fact that three basic elements determine just how safely, how economically, and how efficiently we move about. These elements are the roads themselves, the vehicles which operate over these roads, and the drivers who operate the vehicles.

My topic today has to do with what is being done in an effort to bring about a professional approach to the overall problem—not a piecemeal attack either on engineering, or enforcement, or education. It is the field of traffic management and accident prevention which hopes to bring together all three "E's" for a coordinated program.

Taking that as a focal point of my remarks today, let us move on to three major points:

1. General elements which constitute a balanced action program for traffic management and accident prevention.

2. Oregon structure for getting the job done.

3. A quick look at some of the results of this coordinated attack on the problem.

A BALANCED ACTION PROGRAM

The President's Committee for Traffic Safety has taken the best thinking of traffic experts from across the nation and molded their experiences and philosophies into a general guide for a balanced action program. Each element has specific responsibilities. In addition, all elements are tied together for a unified effort in meeting major needs.

Citizen Support Foundation

The base of our balanced program must have as a foundation citizen support. Then we can begin to build with facts and laws. Our structure begins to take shape as we consider each element as a pillar in a building. These elements include roads, traffic engineering, the vehicle, public education, school education, driver licensing, and the police and the courts.

If our building or program is to have cohesiveness, the individual elements must be of balanced strength and capped with coordination and teamwork.

In other words, I am saying that the best highways in the world alone will not solve the entire traffic accident problem, just as enforcement alone or education alone will not do the job.

Executive Responsibility

The chief executive of any state and, for that matter, the chief executive of any community, must be concerned with the entire traffic problem, but he must likewise be concerned with many other problems. He cannot afford to become bogged down in a mass of detail, nor does he have the time to meet individually with each concerned department head to discuss the many and diverse problems of traffic safety. This is particularly true when one realizes that there are many times when these problems cut across departmental lines and that the different agency heads may also have divergent views on what might solve some particular problem.

In spite of the demands made upon him, a chief executive must realize that he is held by the voters to be responsible for the program or lack of program undertaken by the various departments. This is true in safety as it is in other areas of offical concern.

The most effective method of making certain that there is teamwork and that the maximum job is accomplished is to employ the coordinating committee.

Recognizing this need for coordination is one thing. Doing something about it is quite another, for it requires breaking down the established patterns on single agency responsibility and action, which sometimes may be zealously guarded by those fearful that their domains are being invaded.

It has been recommended for many years that each state, as well as each city, should have a coordinating committee of officials to plan traffic management and accident prevention programs. Yet, as late as 1957, only 17 states reported active coordinating committees of officials. The number has increased slowly, but it has been only quite recently that the field of coordination has come into its own to such an extent that, for example, New York University is now cooperating with the states in presenting a series of short courses on state traffic safety management. The courses cover methods of developing a unified program, utilizing resources for maximum effort and resolving problems through specific plans for coordinated action.

I am pleased that Oregon has taken full advantage of these courses by sending our executive secretary to each of the three short courses that have been made available.

THE OREGON STRUCTURE

That brings me to the Oregon structure for coordination through a commission. Each individual element in Oregon's program for traffic management and accident prevention has shown steady progress over recent years. The machinery for increasing coordination was established in 1956 when the Governor wrote an executive order creating the Oregon Traffic Safety Commission. It has been re-established by each succeeding governor since that date.

Commission membership consists of the elected or appointed heads of eight agencies of state government with responsibilities in the traffic safety field, as well as two citizen representations.

Membership consists of the Chief Highway Engineer, Director of the Department of Motor Vehicles, Superintendent of State Police, Superintendent of Public Instruction, Attorney General, Administrative Assistant to the Chief Justice of the Supreme Court, State Health Officer, and the Chairman of the Industrial Accident Commission.

It is my role, as Executive Assistant to the Governor, to serve as chairman of the commission. Staff work is performed by personnel of the Traffic Safety Division of the Department of Motor Vehicles, with the manager of that division serving as executive secretary to the commission. The Director of the Department of Motor Vehicles serves as vice-chairman of the commission. Thus, the Motor Vehicle agency provides the budget for the commission activity.

Commission Role

The commission's role is to develop and coordinate the official program for traffic safety in Oregon in the areas of education, engineering, and enforcement, and to serve as advisor to the Governor on matters relating to traffic safety.

Meetings are held every six to eight weeks to review the traffic situation and to discuss development of public safety education activities, as well as a total program of accident prevention.

The operating committee, composed of one representative from each of the four departments with major responsibilities—highway, state police, motor vehicles, and education—convenes approximately two weeks in advance of each commission meeting to review commission business and prepare agenda.

THE RESULTS OF COORDINATION

A better grasp of the scope of commission activity in Oregon can be gained by a brief look at some of its work over the past five years.

It developed Oregon's first action program for traffic safety, basing it on recommendations contained in the state's annual inventory of traffic safety activities. While not all the recommendations have been adopted, we have been able to make progress in several areas, including development of a standard police accident report form now in use by many cities and counties, removal of the necessity for obtaining written consent before a chemical test can be given to an individual arrested for driving while intoxicated, and establishment of standards for recruiting, training, and supervising school bus drivers.

In each of the above cases cited, more than one agency and even more than one level of government was concerned with the action taken—police departments, courts, prosecuting attorneys, schools, licensing officials, and medical authorities all played a role in developing the final program.

The commission also arranged for Oregon participation in the Cornell Crash Injury Research program. This, too, required teamwork of several state departments, including the State Police and the Board of Health, working through county medical societies and hospitals.

More than four years ago, the commission recommended the use of seat belts to the public. It took its own recommendation seriously and, through its recommendation to the Governor, seat belts have been installed in state-owned vehicles. As a result, a number of state employees have been saved certain serious injury or death.

The group has sparked several special studies, including studies of school safety patrols, high school driver education, chemical test legislation, and speed laws. It recommends legislation and it has in the past endorsed or opposed legislation introduced by individual legislators or other groups.

As another example of how commission activity often crosses departmental lines, let me cite the commission's activities with regard to the state's speed law.

Several years ago, the commission after much debate among its members decided to support a change in Oregon's speed law which would retain the basic rule but would make posted speeds maximum speed limits in the state. Several agencies at the state level were concerned with the change—the State Police, Highway Department, and Department of Motor Vehicles. In addition, city police and courts also have a vital interest in the problem.

It took, as you can imagine, considerable time to determine first the basic principles which should be incorporated in a proposed bill, and second, the specific speeds which should be established. When the discussion started, I am certain that not more than two of the then ten commission members agreed wholly on the bill's wording or the limits to be specified. However, through coordination we were able to go before the 1961 Legislature with a unified view—a bill to which every concerned department could subscribe.

I wish I could report that with this backing we were able to secure passage of the bill but, as most of you know, we were not.

The commission took its next step in this area late this past summer when, as a stopgap measure, it recommended to the Highway Commission that it undertake a program to extend its speed sign postings in rural locations. This means that over a period of time, each highway in Oregon will be posted or zoned for the speed engineers consider the reasonable and prudent speed for the area—whether that speed is the prima facie 55 mph set by law, 60 or 65, or even a speed below 55.

These signs, of course, will not make the posted speed the top legal speed, but it is the commission's view that they will provide drivers with a realistic definite guide as to what is considered the safe speed for each area in which they drive. The Highway Department accepted this recommendation and the speed signing program is now advancing. A change in the law itself must await the next session of the legislature, at which time, I am certain, the commission will again request passage of a bill establishing maximum limits.

The commission serves the important purpose of bringing together all of the state's most experienced people in this field to discuss often times mutually related problems. It also permits the Governor to have the benefit of their combined experience and advice, focusing on one specific problem. The Governor, in turn, can bring before it certain problems that have been called to his attention by the public.

CHALLENGE OF COORDINATION

I would be the first to admit that the challenge of coordination has not been fully realized in Oregon, but we are, I believe, moving in the right direction so that the public and their elected representatives in the legislature will have placed before them a program representing the thinking of all state agencies concerned with administering the many facets of traffic management and accident prevention. Such coordination is essential if needed progress to meet the challenge of the years ahead is to be made.

It is vital that we enlarge our thinking with respect to those programs which relate to traffic safety. Each agency, as it plans its programs, must be prepared to consider what effect its action will have on other agencies of both the state and the city, and we must, at times, be prepared to compromise our point of view for the total betterment.

In building new highways, for example, it is vital to take into consideration well in advance what effect they may have on deployment of enforcement personnel. Freeways, especially, have a marked effect on enforcement.

In enforcement, we must think not only of what effect certain laws or changes will have on rural enforcement—the area of concern to our State Police agency—but what effect it will have on the activities and operations of city police and counties.

Our accident records must be kept in such a way that they will be mutually helpful to our engineers in designing and controlling traffic, to our police in utilizing modern enforcement techniques, and to our psychologists and educators in trying to better understand the human factor in accidents.

We need to remember than an army in the field depends for its success upon coordinated action. The individual components are not permitted to go off in all directions without regard to the total operation. If we are to have success in the war against accidents today, and be prepared for the days ahead, then we must plan strong coordinated action by all elements. This, of course, will require the full support from all those in the front lines of engineering, education, and enforcement.

Then, and only then, can we really succeed in our efforts.

TRAFFIC SAFETY
Safe Driving Habits

Walter C. Lunsford

It is a pleasant experience to be a part of a conference that takes in the scope and magnitude of the highway traffic problem as yours does.

Today, everything is dependent upon speed and time-saving devices. Even coming to Oregon by air gives one a feeling of closeness and togetherness. The jets now get you to your destination almost before the stewardess can gather up the lunch trays. Most likely this will seem primitive before we know it. An airplane official was recently speaking to a group of aviation people in Washington. He forecast the day when superjets would take us from Seattle or Portland to New York in a couple of hours.

General Motors has an experimental car at its test grounds that is controlled electronically. An electric cable is placed in the road surface, and a control device on the front of the car keeps it over this line of direction as a magnetic attraction. A radar prevents the cars from crashing into each other. There is no steering wheel. The proponents are confident that such a highway, with appropriate devices on cars, will permit vehicles to travel 100 mph with only a few feet between cars.

The men who are working on this will tell you that we already have over 76,000,000 vehicles using the nation's streets and roads, and by 1975 we will have 110 million. We <u>must</u> find ways to carry more traffic on the roads. There is no question about that.

This brings us to the problem of driving which faces us now, and which we know will get steadily worse. One of the main factors contributing to our chaos on streets and roads is that people, generally speaking, do not really know how to drive safely. There is little uniformity in driving practices and habits. The reason for this is due to the fact that the earlier drivers moved from the buggy to the Model T, and picked up their driving by a hit-or-miss procedure. Each one thought that what he was doing was best. As time elapsed, these practices were passed on to the next generation. It is amazing that many of us have a feeling that because we have not been caught doing something, or not involved in an accident, that it is safe to do it. Then one day a driver commits this act, and someone else coming from the opposite direction or from the side does not understand. The result is that on the day this driver has his first accident is the last day of his life.

This could be the result of any number of things that people commonly do when they drive, such as:

Pulling away from the curb without looking or signaling.

Making a left turn from the far right-hand lane and into the path of oncoming traffic.

Driving onto the highway from a farm road or sideroad without coming to a complete stop.

Failing to make a complete stop at a stop sign or signal.

Changing lanes without signaling or having proper clearance.

Following too closely.

Getting out of the car on the street side.

Passing without proper clearance and visibility.

Looking off the roadway, not thinking about the driving situation, and talking too much.

Lighting a cigarette while trying to drive.

These practices become habits because we do them over and over, again and again.

Your driving habits can kill you or save your life. By practicing the safe act over and over we will automatically do the proper thing in driving, even though we many not be thinking consciously of the driving situation.

What is a habit? The dictionary defines habit as a tendency toward an action or condition, which by repetition has become spontaneous. How do we develop safe habits of driving? Should all drivers have these habits?

In order to develop a generation of drivers with safe driving habits, all drivers should have a standard course of driver education and behind-the-wheel practice as a qualifying condition to get a driver's license. This would acquaint each driver with what to do and, when given a course in driving instruction, would explain <u>how</u> and why these acts should be practiced <u>every</u> time the individual drives. This would also help to standardize our driving habits so that drivers would be more uniform in their driving.

All aviation pilots are given basic and advanced training before they qualify for a license. Each one practices what he has been taught until it becomes automatic and he will react properly to situations and conditions. He does not have to think it out—if he did it might be too late. The same is true of automobile drivers. We are in a hurry each time we get behind the wheel. If we have been taught the proper things to do, and practice them until they become habitual, we will automatically react to situations in the proper manner. If we have to wonder what to do, and guess or think it out, by then it is too late.

There is an old saying that "practice makes perfect." I say that practice makes perfect what you practice. This can be a desirable habit or an unsafe or undesirable one. To assure safe driving habits in every driver, everyone should have a standard, uniform course in driver education by a qualified instructor.

With all drivers equipped with the knowledge of how to drive, and a repertoire of safe driving habits, there will be less confusion among drivers. They will have more confidence in themselves as drivers and will cause fewer delays at intersections and focal points of traffic, and more vehicles will be able to move over our streets and roads at a faster rate with fewer collisions.

A big job lies ahead for public officials and civic leaders with the prospect of more vehicles in the near future. Here in Oregon, as well as in the state of Washington, only about one out of five high school boys and girls was enrolled in standard courses of driver education in 1960-61. These students have a 50 percent better driving record than untrained students.

You know the values of this course. You can do much by contacting your school administrators on this matter to learn why this course is not provided for all eligible high school students. Your states are far behind most other states in teaching driver education.

Remember that in order to increase the driving abilities of young drivers they should be taught what to do and how to do it, then to practice these techniques until they become habits. These habits will help the drivers to move their vehicles in a safer manner, and will uniformly improve the driving of most drivers.

A habit is formed in our nervous systems as a result of repeat performances. Just the acts of fastening your seat belts, signaling your turns, always stopping at stop signs, and checking over your car may seem relatively insignificant to you. By always doing these things, however, they will soon become habits and could save your life, even without your thinking.

We cannot wait for the manufacturers and engineers to put univacs, computers, and automatic controls in our vehicles. Too many lives are being lost now. These can be reduced by developing safe driving habits.

You people are in a position to help assure that the young drivers will have least a 50 percent better chance of survival in automobiles. Therefore I urge you to support a plan that provides driver education for all students from which they might establish these safe driving habits.

At least it is worth the effort, don't you think?

NATIONAL ASSOCIATION OF COUNTY ENGINEERS' MANUALS
County Road Management

C. Arthur Elliot

Introduction

The 3000 counties in the United States vary greatly in size, wealth, population, and physical characteristics. Accordingly, there is no distinct pattern among counties with respect to road problems.

One problem common to all counties, however, is the growing demand for better roads and improved road services. As motor vehicle ownership and use increase, the task of providing an adequate road network becomes more complex. Obviously, no one needs to remind county commissioners and county engineers of the problems to be faced in keeping pace with the growth in highway transportation. Their main concern is how their county, and every county, can best organize to meet its road needs yet retain local responsiblity for county roads.

In introducing the topic of county road management, it may be helpful to trace briefly its development. Before the days of the automobile, counties were responsible for what little rural road building was done. Initially, counties were divided into small road districts, managed by elected officials. With the automobile, trips became longer, crossing district and county lines. As more and longer trips became the rule, highway leaders in some counties saw that road districts were too small and responsibilities too divided to meet new travel demands. They felt that county roads could be better planned and improved if standards of policy and construction were applied on a county-wide basis. Also, they recognized that counties needed engineering aid in implementing road activities.

Highway leaders envisioned an engineer-board plan of management as an ideal solution. This plan would serve a twofold purpose: to preserve local authority, yet provide maximum efficiency in road affairs.

Under the engineer-board plan of management the county board makes policy and a professional engineer sees that it is carried out. The board has available the advice and counsel of an engineer when needed on policy matters. The county engineer-board road management plan gained in popularity after congress required states to have road management plans to qualify for federal aid for highways. To be eligible for federal aid, the states were required to organize highway departments staffed with engineers. This requirement indicated to counties that in addition to money and good management, specialized engineering skills also were needed to produce adequate roads.

In establishing county engineer-board management plans, some states required or permitted the appointment of engineers by county boards. In other states, the adopted plan provided for experienced road superintendents, rather than engineers. Still other states made no changes, leaving road management under elected road officials who lacked specialized road knowledge. This situation still exists in many counties.

However, the board-engineer plan has met with measurable success. Over the years many counties have gradually improved and expanded their management operations. By experience and advancement, although slow in many cases, they have determined the necessary actions of management first; then they have worked out good methods of doing them.

The board-engineer type of management is a team effort. Areas of conflict have been narrowed and a harmonious atmosphere of mutual respect is present. The engineer-board relationship is founded on the understanding of how both must work together to get things done effectively.

However, on a nationwide scale there is still no uniform pattern for county road management. Road management methods produce different results—some good, others poor. Generally, those counties that have followed the original concept of the engineer-board road management plan have produced the best results.

There is still this problem. Even among counties described as well managed and under an engineer-board plan, there are notable differences in results. Why is this so? The answer is plain—the basic and uniform practices necessary to build and maintain a county road system properly are not being carried out correctly. New board members and engineers, for example, are inclined to perpetuate existing practices—both good and poor. It is desirable, of course, to have uniform management practices in every county, but where does one find the guide to these practices? What are the commandments of good management? What device can be used to appraise management actions?

The National Association of County Engineers, in response to the need for sound practices in road management, has developed a plan that is adaptable to counties of all sizes and locations. Through its Central Research Committee and a Special Committee on Relationship of County Board and Engineer, this organization is now gathering, selecting, and publishing the best road management practices in the nation. The NACE Plan is being published in three parts: Relations, Actions, and Methods of Management.

A series of manuals relates the use of sound management practices and describes the board-engineer relationship necessary to apply these practices. The Automotive Safety Foundation and the U.S. Bureau of Public Roads have provided research funds to carry out this program.

In the final analysis, the goal of efficient county road management is building and maintaining a system of county roads. The NACE Plan will help achieve this goal regardless of the size or location of a county. Its practices can be adapted to various road department needs.

The NACE Road Management Plan begins by listing these basic actions under ten functional titles: office, personnel, information, programs, plans, construction, relations, research, maintenance, and suburban development.

Under each of these functional titles is listed the detailed activities which take place—to greater or lesser extent—in a county road office.

Office

The county road office is the seat of management. It provides housing for records and the space to carry out its activities. The staff size and work load will vary with the size and road responsiblity of each county.

A few of the principal duties carried out under office functions are: organization, direction, accounting, budget, purchasing.

Personnel

Daily activities of construction and maintenance on a county road system require many types of road equipment and employment of persons with many skills. These activities include: selection, compensation, training, direction, separation.

Information

Because roads concern all citizens, each county should provide accurate information to acquaint its employees and the public with road policies, needs programs, and benefits. Information activities include: to each other (between Board and engineer), to employees, to the public, to groups.

Advance Road Programs

Improvement programs are the advance determination of road needs and the orderly scheduling of necessary work over a period of years. A long-range program generally extends for ten or more years. Short-range programs of one to five years are prepared from the long-range plans.

Plans

Once specific projects have been scheduled for improvement, plans and detailed cost estimates are necessary. Under these plans the following activities are included: surveys, design, right of way, construction plans.

Construction

Construction is building the road as detailed by the plans. Included are: specifications, contracts, material control, supervision, payment.

Intergovernmental Relations

Within a state there are many governmental agencies with jurisdiction over roads and streets. However, these agencies—state, county, and municipal—are engaged in building an efficient transportation system. In this endeavor all agencies must coordinate their efforts—that is a working intergovernmental relationship. Necessary relations include those to: highway department, Bureau of Public Roads, municipality, and association.

Research

Research is the investigation and determination of better methods to build and maintain roads. County road management presents problems which generally differ from those of the state or municipalities. Research should be directed to the problems found in these three basic areas: existing, needed, and application.

Maintenance

Maintenance is the work performed to perpetuate a road or structure in good condition and to keep traffic moving. The everyday tasks such as mowing grass and smoothing or repairing road surfaces are considered routine maintenance. Reconstruction or improvement of existing roads is called improvements or special maintenance. The division of maintenance into routine and special allows costs to be segregated, and gives the necessary facts for planning and control of operations. The five principal maintenance activities are: standards, cost records, reporting, operations, and results.

Suburban Development

The increasing urbanization in counties is of real concern to boards and engineers. Road transportation plans affect other aspects of development such as land use patterns and public works. Many county engineers, in addition to road duties, have responsibility for public works, approval of subdivisions, and trash disposal. They should be aware that solutions depend on a comprehensive, not piecemeal approach. These basic activities are necessary for a comprehensive approach: population growth estimates, land use plan, road plan and zoning plan, subdivision control, and other services.

Actions of Management Chart

Here the actions of management are listed under their functional titles. This arrangement provides a practical basis to separate the broad subject into small components. This reduces road management to simple and familiar terms we all can understand.

A by-product of the chart is that it points up, both to the engineer and the board, the responsibilities of each.

The chart also was used to develop a plan by which members of the National Association of County Engineers could work together on the details of the various actions. At the same time, by using this plan, work was coordinated and guided to its final goal.

Organization Plan

The Executive Committee of the Association appointed a Central Research Committee to carry out the study program. Advisors to aid this committee also were selected. The Central Committee formed subcomittees, each having definite responsibilities keyed to the basic actions chart.

County Road Management Guide (A step-by-step plan for improvement)

The plan described in this booklet can be termed the long-range work plan of the organization. Actually, it was a research project to determine the necessary management actions. Each committee began work by first listing activities considered necessary and then writing descriptions of these activities.

The County Engineer and His Relationship to the County Board

The introduction described the evolution of county engineer-board road management and defined this alliance as a team effort. Each member contributes individual skills and training. The board, representing its citizens, is vested with legal authority and responsibility for the county road system. The skill of board members is best employed in making decisions affecting roads. The engineer uses his training and experience to aid the board in arriving at decisions. His job is to carry out decisions.

One popular statement that sums up this division of duties is, "The board determines policy and the engineer directs that policy." Although this statement is generally correct, the team relationship is considered to have more profound implications. In actual practice, board decisions often depend on factual information that can be provided only by the engineer. In order to direct policy decisions successfully, the engineer must fully understand them.

If we are to understand the desirable relations that produce an efficient road management team, we must know the specific duties of the team, some examples of how board policy is determined, and the engineer's role in working with his board.

These examples are designed to guide the management team into productive relations. A logical beginning point is the relative importance of a county board in road management.

COUNTY BOARD

Legal authority to build and maintain roads

The legislative purpose in giving road responsibility to the county board is to place these roads under local control. The board's responsibility is to build and maintain an adequate road system. This must be accomplished within the legal framework and with the approval of the county's citizens.

In the board-engineer management plan, legislative direction requires or permits the employment of an engineer to aid the board in its road responsibility. This creates a road management partnership—a management team.

COUNTY BOARD

Determines how to obtain adequate roads

ENGINEER

Furnishes technical skills
Furnishes management skills

COUNTY ROAD MANAGEMENT

The management team has these responsibilities: the board within a legal framework is to provide an adequate road system. The engineer is to use his skill to aid in bringing this about.

The board functions as the county road authority by making decisions. It legislates on the many specific actions entailed in road building and maintenance. The engineer, in addition to providing factual information, carries out these decisions by directing road activities. The final product of this joint effort is county road management.

For a successful partnership between the board and engineer, each must understand their interrelationships in all phases of road management. A joint committee of county engineers and commissioners was assigned the task of listing these relationships.

Relations Guide

This is the published report of this committee. The report first reviews the broad general responsibilities of the board and engineers.

Engineer - gathers and prepares factual road data; explains data to board

Board - uses facts to make decisions (policy) on road management actions

Engineer - consults with board to attain full understanding of their decisions (policy)

Board - refers decisions (policy) to engineers to direct and carry out

The engineer provides the board with road information. He explains the data to the board and they use it in making decisions. As these decisions become policy, the engineer should know the reasons behind policies so that he is better able to direct road operations.

Engineer - uses technical skill and knowledge to build and maintain roads within the board's decision (policy)

Board - sees that engineer carries out their decisions (policy)

Board - appraises results

Engineer - appraises results

Road policies of the board are translated by the engineer into the operations of building and maintaining roads. It is the board's duty to see that its policy is carried out by the engineer.

These broad general principles apply to all functions of management and some of the individual actions. Several functions are used to demonstrate this.

Office Operations Function

Engineer - Directs activities, submits records method; prepares, presents annual budget; directs total operation within budget; directs purchases under procedure

County Board - Establishes office and records method; adjusts and approves annual budget; provides funds for budget; establishes purchasing procedure

Personnel Function

The performance of daily road tasks requires employees with skill and experience. Their efforts must be organized and directed toward specific tasks. Better results are obtained if employees are selected for specific skills, provided with proper equipment, and are trained in its application.

Engineer - Provides information on employees; methods of reporting; methods of training

County Board - Decides a method of selection; establishes pay schedules; provides a method of payment

Information Function

The task of county road management is made easier if the road department has the confidence and support of the public and its personnel. The key to confidence and support is the proper exercise of the information functions. This calls for a systematic information plan.

County Board - Informs public of road problems; knows public reaction to policies; decides how to release road information

Engineer - Informs board of road problems; informs employees of road plans; arranges news material about roads

Program Planning Function

Improvement programs are advance decisions of the necessary road needs and the orderly scheduling of those needs. Programs provide a basis for fiscal planning and give an orderly sequence to improvements. Programming activities include road inventory, classification, and the translation of road needs and their arrangement into long- or short-range programs.

<u>Engineer</u> - Suggests classification plan; determines improvement needs; prepares long-range improvement plan; prepares short-range improvement plan

<u>County Board</u> - Approves and adopts classification plan; studies improvement needs appraisal; adopts a short-range improvement plan

<u>Plans Function</u>

The first step in preparing construction plans is the accumulation of field data that records measurements and conditions. From these data is projected the desired facility designed to serve present and future traffic.

<u>County Board</u> - Authorizes survey and plans; approves plans; determines method to obtain rights of way

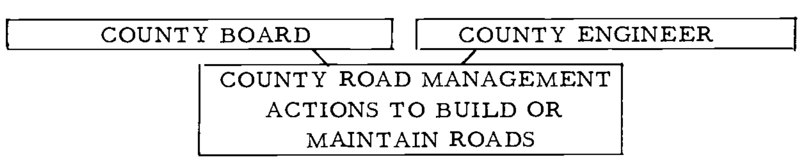
<u>Engineer</u> - Makes authorized survey; prepares plans, including rights of way needed; estimates costs of improvement

<u>Construction Function</u>

For a specific improvement project, completed plans are essential to carry out the many details of construction, including supervision and approval of completed work.

<u>Engineer</u> - Explains construction details; prepares proposal for bids; supervises construction activities

<u>County Board</u> - Decides how to do work; awards contract; approves completed work



While it is essential to enumerate the necessary actions and to describe each for uniform understanding, there is one more needed element. What is the best method that can be employed to carry out each action?

The final objective of the county management program is geared to provide this answer. The six committees and nine subcommittees, formed to date, have devoted their attention to writing methods manuals for each of the management actions. The first completed manual, Advance Road Programming, was distributed recently. This manual, the product of Committee II, contains details of program development.

Advance programming is one of the important functions of county road management. It should be a continuous activity. The engineer's task is to gather and analyze facts and to prepare and recommend construction and maintenance programs. The county board has final responsibility to activate the program. The manual explains the necessary steps.

This manual is a detailed work guide complete with sample work forms and examples. Its purpose is to bring to all counties a firm proven procedure.

Road Experience Records

Also completed and distributed is our accounting manual. Included are definitions and procedures similar to the AASHO accounting manual.

The importance of accurate records and how their use enables counties to perform their road duties more effectively is emphasized.

Public Relations

Every county road agency must give information about its activities. Recently distributed is our public relations manual explaining why it is necessary to provide road information and also describing methods to give this information. Examples of press and radio releases are provided.

The chart on the public relations process outlines how the county road management team can provide an information program. It includes the following: organization, personnel, purchasing, and comprehensive planning.

Committee work on these four manuals has been completed. After final review by the Central Research Committee and editorial work, publication and distribution will follow.

Work is under way by active committees in preparation of the following manuals: intergovernmental relations, design standards, maintenance standards, definitions, zoning control, roads and streets, drainage and sanitation, location of utilities.

Conclusion

In addition to the 15 manuals published or being compiled for publication, we propose to prepare about 10 additional documents.

We view the preparation of these manuals as a first-stage development. Probably the final word will never be written, for new and better methods will always be found. The real value of this research work will occur as counties accept their responsibilities to improve county road management.

We believe our program will help in this decision because it explains what road management is, the relations conducive to a harmonious board-engineer management team, and provides modern methods so their actions can be carried out effectively.

NATIONAL ASSOCIATION OF COUNTY ENGINEERS MANUAL
NACE Aids

Pat Thompson

Definitions are necessary, particularly in engineering where colloquialisms often confuse the issue. In this respect, NACE is in the process of preparing a definitions manual so that we all may speak the same language in our writing and public orations. This is only one of the many manuals available.

To understand the full importance of NACE aids, let us first determine the character and qualities of the average county engineer who is going to use them. First of all, he is a technical man. The day and age of the "grandfather clause" county engineer is gone. Most of them are now college trained and experience-hardened veterans of the public engineering wars. The very fact that they are county engineers indicates to me that each of these persons has a very dedicated streak within him, because most of them could enter into industry at a higher salary, but prefer to remain in the challenging governmental field.

Generally, you will find that the county engineer is a gregarious fellow usually engaged in a great deal of civic and community endeavor. He takes a lot of criticism from his fellowmen, especially and often from those he considers his friends, but gets very little commendation or credit for his accomplishments. The county engineer is a man who feels that road department funds are in trust with him, to be used for and in the best interests of the taxpayer. He is also a man that must do a terrific amount of engineering on a paucity of funds.

The county engineer has found that in this day and age no one man is an expert in all phases of civil engineering, and the average county engineer does not have the funds available to hire specialized help. It is at this stage that NACE and its various instructional manuals can step into the game.

The manuals themselves are a composite and careful screening of the best thinking of many nationwide engineers. I have worked on committees as chairman and been represented on several others, and I have been amazed at the thought, effort, and research that each member of a committee on manual preparation puts into the work. Each manual represents hours of individual effort and days of group consultation to present a published book. The composite result is bound to be good, and gives the county engineer the benefit of expert counseling on troublesome subjects at very little cost. All it takes is for the county engineer to expand the effort is to sit down with the manual, digest the material, and apply it to his individual situation.

The publicity manual has a section suggesting the presentation of a slide show. I used this to good effect in my own county. Our total investment for 35 mm camera, projector, screen, and miscellaneous items was less than $600. We prepared a slide show commencing with Board policy through an explanation of budget funds and expenditures, maintenance, construction, and emergency operations, a comment or two on the state-wide organization and our place in it, and ending up with legislative needs.

This slide show was shown first to chambers of commerce, and came into high demand. Within six months we had shown it to every civic organization in the county, including several high school classes and to several organizations in neighboring counties who requested it.

The talk itself consisted of 84 slides and took just one hour for completion. The results were outstanding. In the pre-slide show days, the county often had delegations of from 20 to 40 farmers arriving at once, demanding certain road concessions. In the period following the slide show not a single mass delegation appeared. Either the slide show had painted such a black financial picture that they felt it was no use to come, or it had given them information never before received, and their complete understanding of our situation prohibited pressure demands.

The Board of Commissioners felt they had received a million dollars worth of publicity for the expenditure of one-half of one-thousandth percent of that. You cannot get a much better ratio.

In the matter of road system planning, many counties are just starting to develop and acquire the suburban residential boom that some of us have gone through. The manual on planning can save you many of the headaches and heartaches that we experienced without this aid. It is easy to get caught in the cross-fire between speculators who clamor that planning is holding back the development of the county and the hardshells who prefer the status quo and do try to prevent development.

Any county engineer who is just beginning to suffer the pangs of rapid suburban birth can ease the pains by using the sedative of the planning manual. This manual anticipates by actual experience the problems he will have. These problems arise in almost every case, and being forewarned is certainly forearmed. I plan to use many functions of the planning manual in the development of our Riverview area, which can become the ultra-sophisticated residential area of the Tri-Cities. This, even though I have gone through one such a boom with its trials and tribulations.

Any county engineer has only three basic concerns—time, people, and equipment. Time is the first consideration, and the engineer can be its master or its slave. NACE manuals can help you accomplish tremendous amounts of work with apparent ease and poise because you are reaping the brainstorming efforts of many men.

People are the engineer's second consideration. Here, the problem has resolved into one of getting a profitable day's work for the wages paid. Employees respect their supervision if it is competent. Any county engineer who studies the NACE manuals can gain competence in his work.

The final consideration is, of course, equipment. No longer is it sufficient to look at an equipment purchase merely from the standpoint of how long will it take to amortize the investment. It is recognized there is now a psychology of equipment use. Just because you have always done an ABCE procedure does not mean that a BADC procedure might not be more efficient. NACE manuals give you the benefit of a large variety of experience.

For greater efficiency, NACE manuals help the county engineer eliminate unnecessary steps. It can make the engineer more proficient in the art of making lucky guesses. Actually, a lot of county engineering is only justified by future facts and conditions. Therefore, every county engineer must gamble to a certain extent. The judicious use of NACE manuals can help you stack the odds in your favor.

It is time to forget hunches or prejudices. With the information from the instruction manuals, study the facts available on your own situation. From these, using the manuals as guides, determine what could be the best and worst result from each possible choice that you can make, then decide if your organization could endure the worst possible result without disastrous effects. If so, then you must consider if the possible best result is likely enough and sound enough to take the risk. The engineer then can make his final selection or course of action based on engineering data that offers the brightest prospect for the risk involved. NACE manuals give the engineer an average situation to judge by.

Efficiency can mean different things to each engineer. One thing is certain—efficiency is never static. Each of us has a stake in an efficient program to the extent that we can do a better job for those people that we represent.

NATIONAL ASSOCIATION OF COUNTY ENGINEERS MANUALS

A County's Experience with NACE Manuals

J. R. Kalinoski

Klamath County, Oregon, is for the most part a rural county in the southeastern section of the State of Oregon. The basic economy of the county is composed of three major factors: lumbering, agriculture, and tourism. The lumber industry contributes approximately 33 percent of the buying income for the county; agriculture, 30 percent; and the tourist industry, approximately 12 percent. The remaining 25 percent is contributed by the other various industries such as railroads, educational institutions, and other diversified enterprises. The county has approximately 1600 miles of roads in its public roads system, and approximately 825 miles of these are county roads. At the present time approximately 50 percent of the county roads have been surfaced with asphaltic paving materials.

About two years ago the Klamath County Court recognized the problem in defining a "county road" insofar as the Oregon Statutes were concerned. Most of the individuals hearing the presentation or reading the contents of this paper will understand that Oregon law provides that all public roads are not under the jurisdiction of the counties, but only those roads which have been designated by an order of the County Court to be county roads can be maintained or improved at the expense of the county's general road fund.

The Klamath County Court, recognizing that this feature of the Oregon law has led to a certain amount of arbitrariness in accepting roads into the county road system in past years, appointed what is now known as the Klamath County Roads Advisory Committee. The purpose of this committee is manifold, and for purposes of this presentation I think it would be sufficient to state that one of their primary purposes is to define a "county road" and then to devise a long-range program for improving these county roads with the funds that are available to the county.

This committee did develop a formula by which any public road could be taken into the county road system. The formula sets up a number of criteria which must be met by the public use of the road before it can be considered for designation as a county road. The formula is designed to take into consideration the basic economic factors in the county, and because of this is somewhat peculiar to Klamath County. Although it may be appropriate for other rural counties who have fundamentally the same basic economic factors, it would not be necessarily adaptable to other counties, especially those which are metropolitan by their nature.

Now that the county has a definition of a county road, the committee decided it would be of some benefit to know how the county's road fund was being expended on these county roads. The committee desired to know the amount of maintenance money that was being spent each year, and the amount of new construction funds which were being expended each year from the county's general road fund. In addition, the committee desired to know the amount of monies that were being spent on each individual road, both for maintenance and new construction, in order to determine when maintenance of a road in its present condition became cumbersome and the results of which would lead to some improvement of the roads. The committee also needed this information to determine a reasonable program for road improvements to be included in each capital improvement program of the County Road Department.

There is, of course, only one method available to engineers to determine the amount of money being spent for the purposes which I have stated. This is through a comprehensive cost accounting system. The Klamath County Road Department did set up a cost accounting system which operated for about 12 calendar months prior to the distribution of the National Association of County Engineers Manual on Cost Accounting.

The original system was developed from the scarcity of information that is available concerning cost accounting systems. Needless to say, there were a great number of errors and omissions in the system which were found to be evident following the use of the system for a period of time. Recognizing this, the County Court of Klamath County engaged a certified public accountant to review the system after it had been in operation approximately 10 months, and make recommendations for the development of a comprehensive system to develop an accurate cost accounting system and records.

Coincidental with the engagement of this certified public accountant, this writer was presented with the NACE manual on road experience records in which a cost accounting system is outlined and defined in such a manner that it is suitable for counties of all characteristics. Fortunately, the manual was received in time so that the certified public accountant could review the manual to determine its acceptability in our particular case. The manual met with the approval of our accountant, and subsequently the cost accounting system for the Klamath County Road Department was designed around the NACE manual on road records at the recommendation of a certified public accountant. The cost accounting system has been operating under this guidance for the previous 7 months, and we have found it to be a successful system which could easily be incorporated into our record keeping procedure because of its adequate clarity and simplicity.

I would like to note here that the Klamath County Road Department is not attempting to determine the intricate cost factors which make up road construction and maintenance. Although the Road Department records do indicate the cost of grading and excavation in construction, at the present time it would be impossible to attempt to determine the unit cost of doing this grading and excavation. For the present purposes of the Road Department, it is felt that it would be adequate to know the dollar volume of work which has been completed or is in the process of being completed and, using a certain amount of rational judgment, it is possible for the county engineer to estimate the costs of any proposed project. Klamath County is one of the counties in Oregon in which the Road Department performs all of the road maintenance and construction factors with its own labor and equipment. This includes all phases of engineering, production of materials, and construction of any given road project. Therefore, the procedure for Klamath County to anticipate the costs of a proposed project based upon its experience in a similar project is greatly simplified.

This writer does not feel that the NACE manual is acceptable to be incorporated in all county road department operations without modification. Nor does this writer feel that it was the intent of the authors of the manual to make it adaptable to all county road department operations. Klamath County has one man employed as a cost keeper who also has the additional duties of purchasing agent for the Road Department to handle this phase of county road operations. This one individual is assisted by one woman who uses the pen and ink system for posting the cost records to the appropriate journals and ledgers.

At the present time it would not be feasible for this

County Road Department to enlarge further on the cost records portion of the Road Department operations. However, without the guidance and the assistance of the contents of the NACE manual, it would not have been possible for our Road Department to proceed as far as it has in this field. Therefore, I cannot help but feel that the manual can be modified in any manner without destroying the principles contained in the manual and adapted to any county road department operations.

I would like now to take the opportunity to discuss with you the problem of road planning for county road departments. The National Association of County Engineers has prepared and distributed a manual entitled "Advance Road Records," which has been put to use by the Klamath County Road Department. As I have stated before in this presentation, one of the duties of the Klamath County Roads Advisory Committee was the preparation of a five-year advance plan for capital improvements on the county road system.

To the best of this writer's knowledge, there is no information available to the rural county engineer in this particular phase of county road operations other than the NACE manual. Klamath County has found that the manual on Advance Road Planning has also been prepared with sufficient clarity to be adaptable to the county road operations. The manual sets forth the procedures which can be used to determine the sufficiency of any road in its present physical condition for the present or potential use that the public is giving or will give any particular road. In essence, when one follows the manual, a methodical measurement of the deficiencies in each road is determined in order to rate the sufficiency of the road as it compares to assigned standards for the public use of the road. Klamath County has found that the manual is especially adaptable to the suburban areas of the county, and by utilizing this procedure, which forces a close scrutiny of the physical condition of the road, we were able to determine those roads which could be vastly improved with the expenditure of maintenance funds only, and those roads which would require the expenditure of new construction funds in order to reduce the priority rating of the road.

It appears to be necessary that the engineer, when applying these factors, must recognize the difference between maintenance and new construction. There seems to be a fine, intangible line which should be drawn between the upper limits of maintenance responsibilities and the lower limits of new construction responsibilities. In general, the Klamath County Road Department has considered resurfacing of an existing pavement with a new oil mat to be the lower limits of new construction. The upper limits of maintenance can best be defined by such projects as shoulder widening or the resealing of an existing oil mat pavement. Utilizing these general analogies, the Klamath County Road Department has found it possible to differentiate between new construction and maintenance when considering any individual road project.

If this writer were to be critical of the NACE manual on Advance Road Programming, he would criticize the manual for lack of differentiation between a suburban street or highway and a rural road or highway. In the case of the application of standards in Klamath County, we are finding that because of the economic factors in the county and because of the vastness of the rural areas, it is virtually impossible for us to set one set of standards to cover the suburban arterial as compared to the rural arterial. We are finding that there are certain factors which must be included in the advance road planning program which could not, of course, be included in any manual designed to facilitate all counties.

Let me cite an instance of the problem facing Klamath County. There are four national forests which have jurisdiction over public lands in Klamath County. Three of these forests are partially contained inside of the county, and one of the forests is contained entirely within the county. Since the lumber industry provides approximately 33 percent of the economic base of the county, any county road planning must take this factor into consideration. Studies made by the United States Forest Service have indicated that it costs $0.04 per thousand board feet per mile of road additional cost to transport logs over a gravelled road than it would cost to transport these same logs over a hard-surfaced road. Knowing that the prospective purchaser of public land timber will consider this factor along with the proposed haul route from the harvest area to the lumber mill when bidding for the sale of public land timber, the end result is that a lower price is paid for the trees which are offered for sale. This has a direct reflection back on the revenues of the County Road Department since it will share in the price paid for the trees to be harvested from public land timber sales. Therefore it is necessary for Klamath County to consider this factor and consider the problem of road improvements on timber haul routes to not just be expenditure from the county road fund, but to be an investment in the future welfare of the county road fund and the county as a whole.

Therefore, at the time of writing this paper, it appears to this writer than Klamath County will utilize the NACE manual on Advance Road Programming in a modified form to develop a priority system for improving suburban streets and highways and not necessarily directly compare them with a priority system for the improvement of rural roads and highways.

In general, and in summary, this writer is extremely grateful to the National Association of County Engineers for the preparation of their manuals, which are tending to be of great assistance towards the development of good road management practices on the county level.

In the State of Oregon, the county road department is the one county department over which the county court, or board of county commissioners has complete jurisdictional authority. County commissioners should utilize their road departments to indicate that they are capable of producing good management practices, and county engineers should utilize whatever means are available to them to enhance this attitude. Management and administration of county road funds and procedures and policies are complicated tasks to say the least. Gathering the practices and ideas of counties all over the United States and condensing them into manuals, such as has been done by the National Association of County Engineers, will, I am convinced, lead to the adoption of good standards and acceptance by the public of the plans and programs of county road departments. I cannot recommend too highly the inclusion of these manuals in the operations of any county road department.

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