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HIGHWAY RESEARCH BOARD

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Highway Employment Trends and Requirements

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Contents

Estimating Personnel Requirements for Highway Design

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This paper presents a rational method of estimating personnel requirements and organizing a road design office to meet a given schedule of proposed highway construction.

The first section of this report describes and illustrates the use of a "point evaluation system" based on production of the Ontario Department of Highways Road Design Office, from 1955 to 1959. This system allows the predetermination of the required rate of production, and, correspondingly, the number of staff at various levels for any given construction schedule. It also advises the design engineer of work beyond the capacity of his staff, and which must be done by consultants or other agencies so that the schedule may be kept.

The second section of the paper presents briefly experience with this system over the past two years, and outlines the modifications proved necessary. This method of evaluating the work and estimating personnel requirements is extremely useful to the design administrator and has excellent potential for application to other phases of highway engineering work.

● TWO main and somewhat unusual administrative problems confront the Road Design Engineer of the Ontario Department of Highways. First is the sheer size of the Province of Ontario, stretching approximately 1,000 miles from east to west, and slightly more from north to south. This problem of size, serious enough in itself, is further complicated by the unequal distribution of population and highway development; also by the range of projects designed. Figure 1 shows the population and major highway distribution. The types of projects designed range from multi-lane controlled-access expressways serving the highly developed industrial and commercial areas to the south, to rudimentary access roads constructed to aid development of otherwise inaccessible locations to the north.

The second problem confronting the road design engineer is the immensity of the road construction and reconstruction program.

Prior to 1957, the nature of the highway construction program for any one year was such that it was not known what projects would be chosen for that program until the beginning of that year. Consequently, even though the road design section has been a fully operative branch since 1954, the unpredictable nature of the annual highway program did not allow proper advance design, or time for adequate preparation of tenders and construction drawings. Road design normally had a 4- to 6-month lead on the tender award date. The design and tender preparation phase was rushed, and quality and completeness of design were at times sacrificed in the interest of speed.

In 1957, the Ontario Department of Highways published a need study that had been conducted over the previous two years. This study designated a total expenditure over 20 years of approximately $1.9 billion, at the rate of $95 million per year, on new road construction and reconstruction of existing roads. It also cleared the way for long-range scheduling of work and expenditure, planned according to priority, well in advance of construction; and together with advance scheduling, provided for the first time an ideal opportunity to establish a road design organization based on a relatively stable and predictable future rate and volume of work.

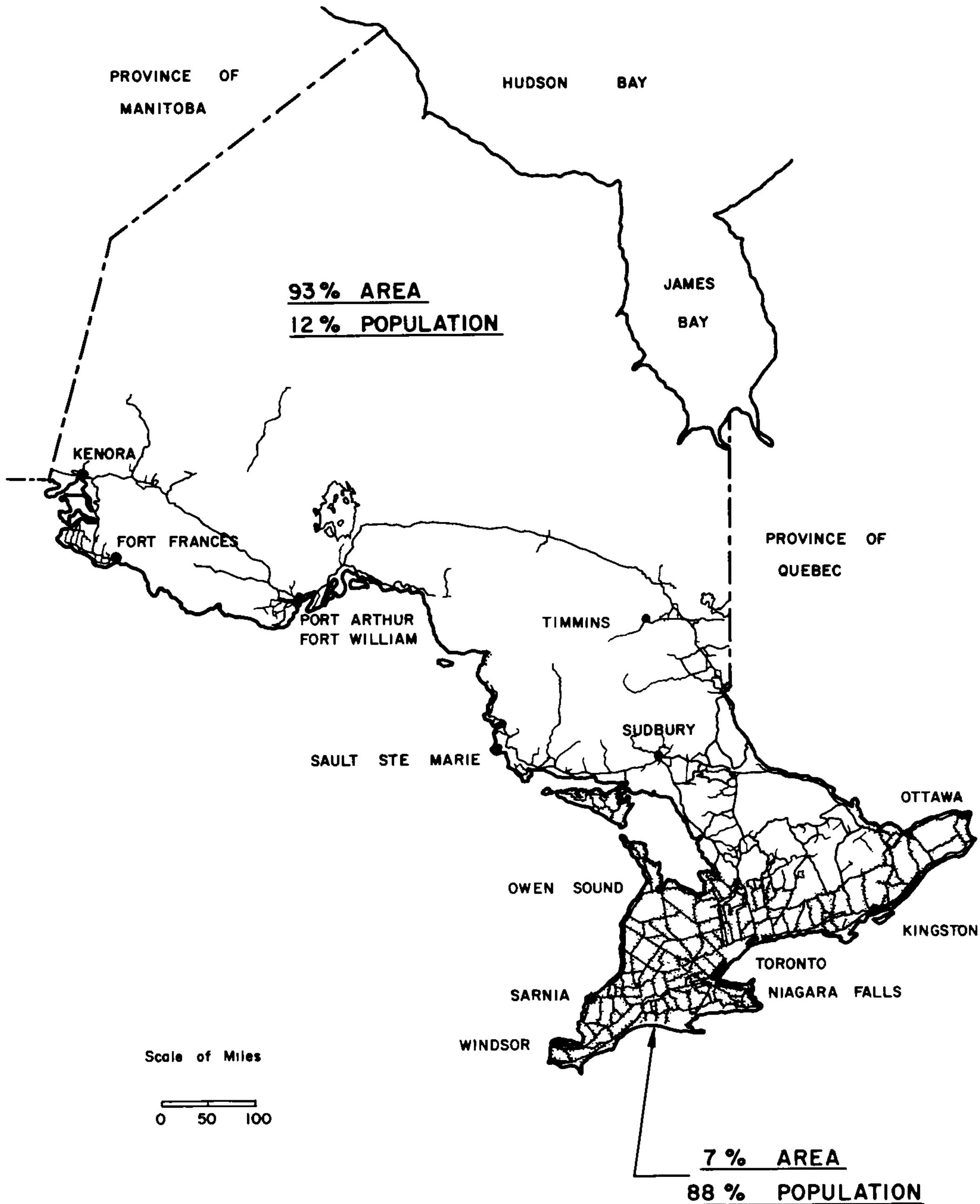


Figure 1. Province—controlled highways and population distribution.

With this purpose in mind, organization, staffing and procedures in the road design office were reviewed in an effort to answer the following questions:

1. What design staff is required to produce the design and tendering information according to the schedule?
2. How should the staff be organized?
3. How may work be assigned so that the schedule may be met?
4. What work should be given to consultants? Where on the program?
5. Is decentralization advantageous and if so, how and to what extent?

PRELIMINARY INVESTIGATION

The two basic functions governing the annual work program are: (a) the annual capital budget, and (b) the construction price index. The first attempt at rationally estimating staff was on the basis of these factors. These factors were indicative generally of staff required in relationship to staff employed in previous years. However, they did not indicate the actual staff required because the previous years' performance was not considered entirely satisfactory, nor did they give any indication of how inadequacies in staff could be predicted in advance.

TYPE OF WORK	PROJ. DES. ENG. (DAYS)	EST GROUP (DAYS)	FIELD STAFF (PARTY DAYS)
MINOR STRUCTURE	2	4	2
MINOR STRUCTURE WITH RLWY BOARD ESTIMATE	3	6	2
MAJOR STRUCTURE	3	6	4
MAJOR STRUCTURE WITH RLWY BOARD ESTIMATE	4	7	4
MINOR INTERCHANGE	4	16	5
MAJOR INTERCHANGE	6	27	10
D. & G. AND GB. RURAL PER MILE	2	7	5
D. & G. AND GB. URBAN PER MILE	3	8	10
D.&G., GB AND H.M. RURAL PER MILE	3	8	5
D. & G., GB AND H.M. URBAN PER MILE	4	10	10
GB. AND H.M. RURAL PER MILE	1	5	2
GB. AND H.M. URBAN PER MILE	2	6	10
H.M. RURAL PER MILE	1	3	1
H.M. URBAN PER MILE	2	6	10

ABBREVIATIONS
D = DRAINAGE, G = GRADING, GB. = GRANULAR BASE., H.M. = HOT MIX PAVING

Figure 2. Point evaluation system.

A review of literature available on the staffing of design offices of other administrations provided little that would act as a guide in planning the organization because the functions of other design offices could not be compared to Ontario Department of Highways' Road Design Office.

The principal requirement was a method of relating the amount and rate of production of the road design staff to the amount and rate of production required to meet the schedule, and of establishing the number of project design engineers, and number and type of drafting design and field staff, necessary to carry out the work efficiently at the desired rate of production.

DUTIES OF ROAD DESIGN OFFICE

The major duty of the road design office is the assimilation of information provided by the planning branch, the location section, soils, materials and research section, and bridge office, and the correlation and use of this information in the production of the construction drawings and tendering documents. Supplementary to this are the preparation of property requests, negotiation and liaison with municipalities, and the adjustment of utilities. There are also other responsibilities carried by the road design office not directly associated with design and the following is a brief summary:

1. Preparation of Railway Board Estimates for subsidies. These are involved and detailed and require considerable preparation.
2. Field and office reviewing of permits for entrances, buildings and utility installations on or adjacent to highway right-of-way.
3. Checking of proposed road work and other construction projects by agencies, other than the department of highways, but to which the department is financially involved.

4. Research work required for the purpose of: (a) maintaining up-to-date highway design practices; (b) rewriting or revising of specifications; (c) comparing cost estimates as an aid in arriving at engineering decisions on methods of construction, uses of materials and functional design; and (d) preparation of the design and estimating manual and standards and keeping them up-to-date.

THE PROJECT POINT EVALUATION SYSTEM

It seemed that the most logical approach to establishing staff requirements was on the basis of previous production of the various types of staff employed by the design office on each type of project designed.

It was convenient to consider, as separate entities, the project design engineer, the design and estimating groups, and the field survey parties. One day's labor for each of these units was given a value of one so-called "point" of work. Time records for this staff on projects processed through the design office from 1955 to 1959 were reviewed and the types of projects processed and classified into 14 different categories (Fig. 2).

The details and length of each project were placed in tabular form under the appropriate category. The time records for each unit of staff were recorded in similar tabular form, and the average number of days spent by each group on each category of work, per unit, were calculated.

This gave a figure representing the number of working days required by each unit of staff to complete a unit of work in each of the 14 categories.

With a predetermined schedule, and assuming future production similar to the past, and using these point values, the work output required against time available for each of the staff units may be plotted graphically. Similarly the ratio of project engineers to design and estimating groups to field parties may also be gaged for a consistent level of output from each unit on the basis of the established point values of work required.

The value of points allotted to each type of project is shown in Figure 2. Because each point value under the project design engineer represents the number of working days required to complete his work on that particular project, then his limit for any one year's program—taking vacation, holidays, sick leave, and training school or other lost time into consideration—is 200 points.

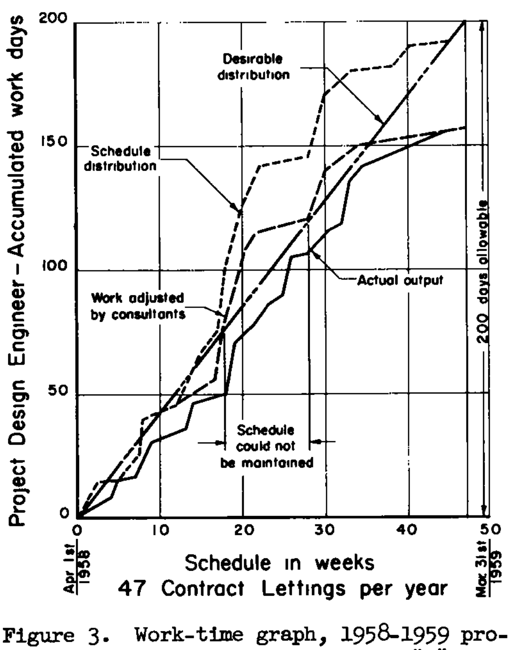


Figure 3. Work-time graph, 1958-1959 program, project design engineer "A".

Figures 3 and 4 illustrate the validity of the point system, showing work-time graphs for two project engineers who worked consistently, and without interruption, on the 1958-1959 program. These two project design engineers are considered as being well trained and competent and capable of putting out a good year's work.

Their work output is fairly steady throughout the year and, where the scheduled work was within their capacity, scheduled dates were met. These graphs also indicate that where the schedule shows a required production at any stage much above their ability to produce, the output still continued at a steady pace and the excess of work just could not be turned out. This seems to verify generally the point values, and the system itself, because a check on 1958-1959 actual production corresponds very well with that indicated by these work-time graphs.

STAFF AND ORGANIZATION

The ideal staff, in numbers and organization, would be that which could prepare the work at a rate which would keep it just slightly pressed to meet the schedule. Staff in excess of this requirement would tend to allow laxity; a smaller staff could cause deterioration in quality. The staff should also be organized so that each level in its individual fields of work is required to perform at the same rate.

To develop an organization complying with these two conditions, a method must be devised to relate the output capacity of the levels of staff within the road design office, and to establish staff requirements on the basis of a consistent level of production from all staff.

As a part of this review it was of vital interest to establish the numbers of staff each project design engineer should have, and the theoretically correct ratio of field parties to design and drafting groups to project design engineers.

The project design engineer is the key man in the actual design work and in the directing of field, design, and estimating staff carrying out work on each project. He is the controlling figure on which the staff and organization should be based.

The actual preparation of a contract is carried out by, and is the responsibility of, the project design engineer. Above this level, staff is chiefly administrative. Under the project design engineer there are field survey parties, and design, estimating and drafting groups. These are composed of the following:

Field party	- 1 party chief - 1 levelman - 1 rodman - 2 chainmen
Design drafting groups	- 1 design draftsman - 1 draftsman group 2 - 1 draftsman group 1 - 2 junior draftsmen

Returning to the project point evaluation system, points allowed on the various projects represent the level of production expected from the project design engineers. To relate and evaluate production levels of other staff, the output of the field staff and the design and estimating staff must be considered on the basis of the developed point values shown in Figure 2. The summation of the total points for all categories of projects listed for the field staff, design and estimating staff, and the project design engineer, indicates by the relationship of their numerical value, the theoretically correct ratio of field parties to design and estimating groups, to project design engineers.

The application of the point values to actual production schedules results in relationship on different types of projects which are not consistent among the field staff, office staff, and project design engineer levels; however, the average of the point awards should theoretically give the required results, because each project design engineer on each program will have a well distributed complement of all of the different categories of projects listed. On this basis:

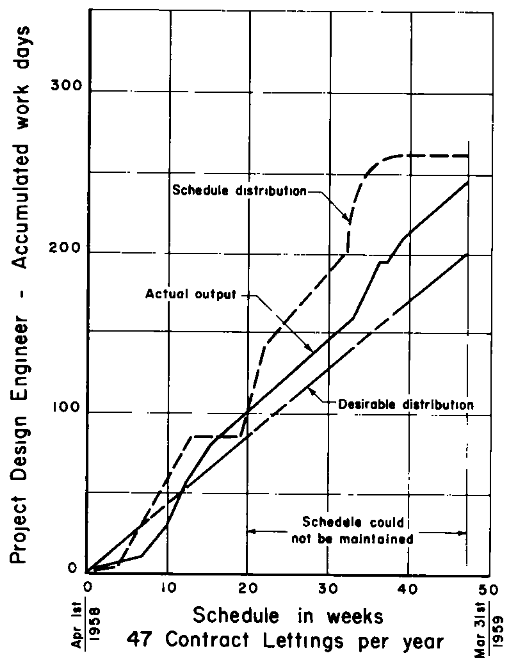


Figure 4. Work-time graph, 1958-1959 program, project design engineer "B".

	Total Points	Average/Project
Project engineers	40	2.9
Estimating groups	119	8.5
Field staff	80	5.7

This means that the project design engineer, estimating groups and field staff should be roughly in a ratio of one project design engineer to three estimating groups to two field staff groups.

The field staff and estimating staff functions should be supervised by seniors of their groups, under the direction of the project design engineer. The project design engineer's staff should be as shown in Figure 5.

THE PROBLEM OF DE-CENTRALIZATION

The organization and distribution of staff for a road design office depends considerably on the problem of a central officé establishment or a de-centralization to regions.

The principle of de-centralization as opposed to central administration has been ably dealt with by W. L. Haas (HRB Bulletin 200).

In 1957 the road design office was de-centralized for field work (Fig. 6), and the de-centralized sections were working in an efficient manner.

Complete de-centralization of project preparation work, was recommended on the basis of the following advantages:

1. Closer contact with the work;
2. Closer contact with the local municipal governments, utilities, representatives, etc.;
3. Better understanding and greater familiarity with the job;
4. Cheaper office space, living accommodations and general overhead expenses, almost anywhere other than in Toronto;

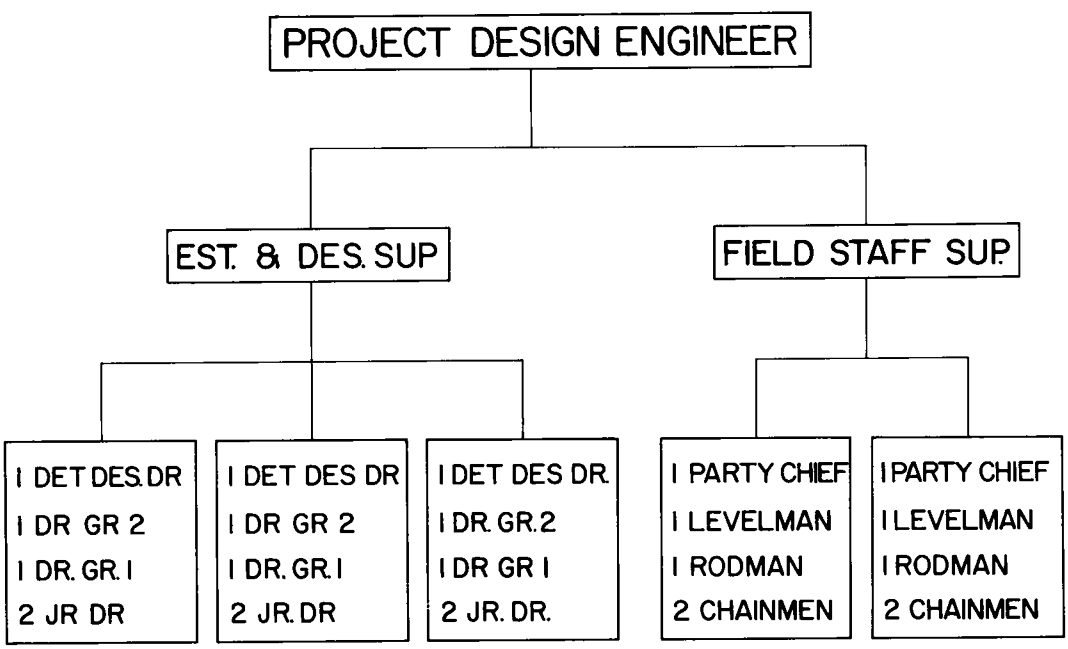


Figure 5.

5. Considerably decreased traveling expenses;

6. Greater inclination of the individual regional offices to work as a team, than when they are grouped together under one roof with some 300 others;

7. Increased pride on the part of the regional office staff in the completed jobs, as they will have to live with it after construction;

8. Greater freedom for the head office group to apply itself fully to administrative policy, standards, manuals, and research phases of the road design office work; and

9. More efficient processing of permits and agreements with closer contact between the regional road design section and the districts.

Some consideration was given as to whether the road design office should be de-centralized to districts (Fig. 6), which have been established for many years, for the purposes of construction and maintenance. A review of the present and past programs in-

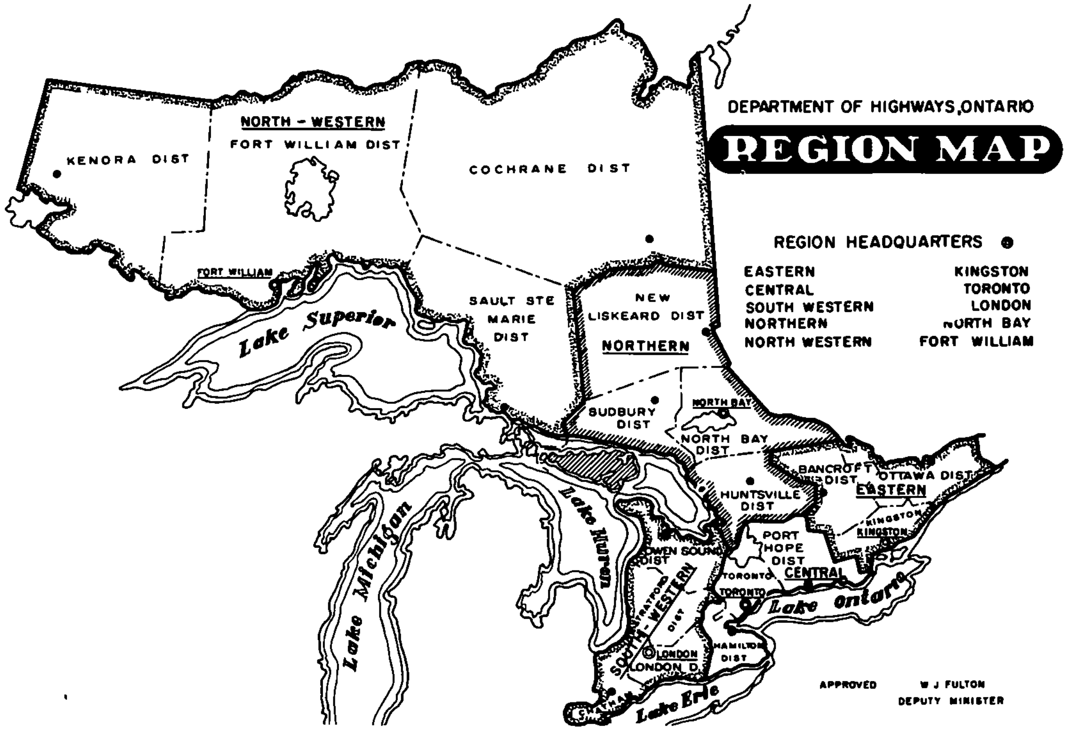


Figure 6.

dicated that the construction schedules varied so much in each individual district, that staff requirements could not be reasonably established with any continuity from one year to the next. By increasing the size of the areas under consideration to the regions established for design field work, a much more stable work load year by year is achieved.

This fact substantiated a recommendation that the regions, as now established for road design office field work, be maintained and that the design staff be completely de-centralized to these regions as necessary to take care of the estimated minimum yearly capital program.

This proposal de-centralized the road design office on the following basis:

Regions	Districts
Central	Hamilton
	Toronto
	Port Hope
Southwestern	Chatham
	London
	Stratford
	Owen Sound
Eastern	Kingston
	Ottawa
	Bancroft
Northern	Huntsville
	North Bay
	New Liskeard
	Sudbury
	Sault Ste Marie
Northwestern	Fort William
	Cochrane
	Kenora

ORGANIZATION ACCORDING TO THE POINT EVALUATION SYSTEM

The theory of rating work load according to the points established under the point evaluation system may be employed to develop the organization for road design on either a central or de-centralized organization basis. The organization charts shown further in this report are based on the assumption that de-centralization will be carried out as recommended.

Hand in hand with de-centralization, the management and administrative responsibilities of head office and the administrative and operational function of the regional office must be clearly defined. The duties assigned the head office are the setting of policy, carrying out of broad research programs, preparation of design standards and manuals, and ruling on decisions that are interregional in character.

The individual regions should have complete authority over the road design phases on projects in their region, subject to the policies and standards provided by head office. The regional office should, therefore, have one senior engineer who administers the policies and direction of head office, and assumes the direction of, and responsibility for, the project engineers and their staff in his region. The regional design office basic organization is as shown in Figure 7.

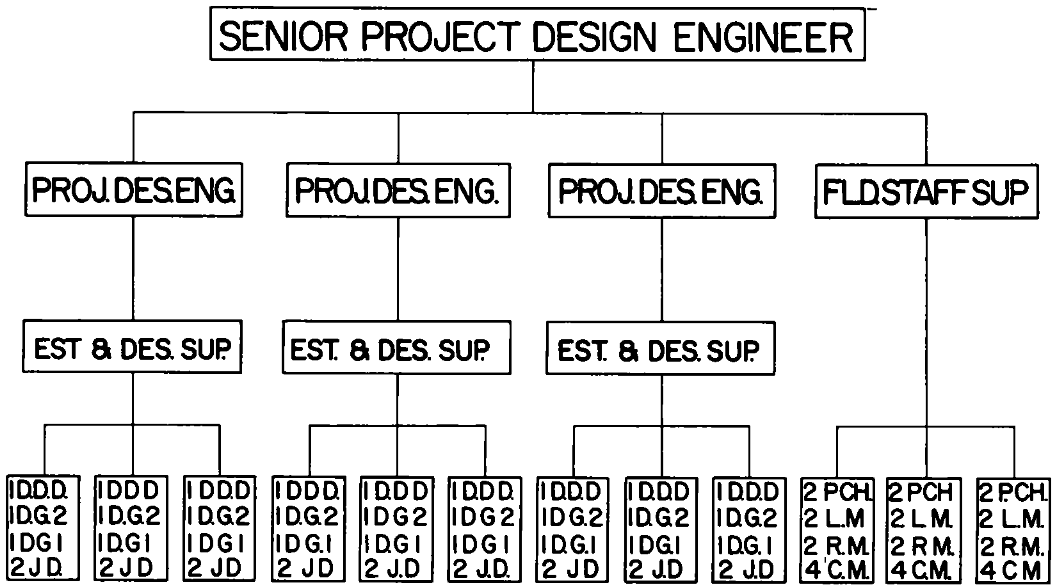
SCOPE OF WORK, AUTHORITY, AND RESPONSIBILITY OF THE REGIONAL OFFICE

The regional road design office will conduct all phases of road design work required for the preparation of the work projects for contracts. It will review and approve permits, agreements, location of utilities and services. It will prepare special engineering reports or comparative estimates as required by the planning section.

The senior project design engineer at the regional office must have parallel authority to the road design engineer on all road design matters within the region, except policy or controversial problems where a head office decision is necessary. The number of problems referred to head office for decisions should be kept to a minimum.

Road Design Head Office

The function of the road design head office should be basically administration and policy, as follows: (a) personnel (interregional administrative only), (b) design practices, (c) research, and (d) standards.



ABBREVIATIONS.–

DDD — DETAIL DESIGN DRAUGHTSMAN
D.G.2 — DRAUGHTSMAN GROUP 2
DG1 — DRAUGHTSMAN GROUP 1
JD — JUNIOR DRAUGHTSMAN

PCH — PARTY CHIEF
L.M. — LEVELMAN
RM — RODMAN
C.M. — CHAINMAN

Figure 7.

Point Evaluation System Applied

The point evaluation system has then been applied to the projects scheduled for each region, and plotted in graph form against the completion schedule. The point value of the 1960-61 program totals about 2,497, which represents 2,497 working days for project design engineers and their staff to complete the program.

The work is divided into regions, as follows: central—608, southwestern—688, eastern—535, northern—380, and northwestern—286.

On this basis then, three project engineers are required in each of the central and southwestern regions, two project engineers each in eastern and northern regions and one in the northwestern region. This gives an allowable work load of 600 points in the central and southwestern regions, 400 points in the eastern and northern regions and 200 points in the northwestern region. From Figure 8 it is immediately apparent that the scheduled work does not coincide with work output, nor is the scheduled production uniform throughout the year. It is obvious that where the scheduled output rises steeply above the desirable distribution (project engineer's capacity), there must be an allowance for the overload of work.

Figure 8 also shows where projects may be expected to drop behind schedule and points out the irregularity of the scheduled program.

To adhere to the schedule, work— over and above the productive ability of the staff —must be assigned to consulting engineers.

Built into the schedule, there is a buffer period of about four weeks between the regional office completion date and the road design office completion date. This will allow short loops of the scheduled program—as much as 16 points per project design engineer—over the desirable distribution "line" and still allow the schedule to be met.

For the purpose of illustration, the point evaluation system can be applied to the 1960-61 program for the central region, with the following results: central region—total points, 608; number of project design engineers, 3; total allowable load, 600 points.

The graph points out the following:

1. The schedule, using up the allowable overload, will be met, up to letting number 24, by Toronto Regional Design Staff.

2. The schedule distribution line rises steeper than the allowable distribution line, to a maximum overload of 100 points at letting number 35. Therefore, 100 points of work on lettings between 24 and 35 must be given out on a planned basis to consultants, so that the scheduled work for road design will fall parallel to and within the allowable overload line.

3. Because this only leaves 508 points of work to be turned out by road design staff, they should complete the 1960-61 program by letting number 47. This will, therefore, allow seven weeks to take care of additions to the program and/or an early start on 1961-62 program.

Application of the point system to each region in a similar manner, then, sets the staff requirements as follows:

Region	Project Design Engineer Groups Required
Central (608 points)	3
Southwestern (688 points)	3
Eastern (535 points)	2
Northern (380 points)	2
Northwestern (286 points)	1

The actual number of points per region is not a true indication of actual staff requirements, because the schedule of required work output throughout the year is also a factor. The project design engineer groups required (as given in the foregoing table) are based on both considerations, as brought out by the work charts plotted for each region.

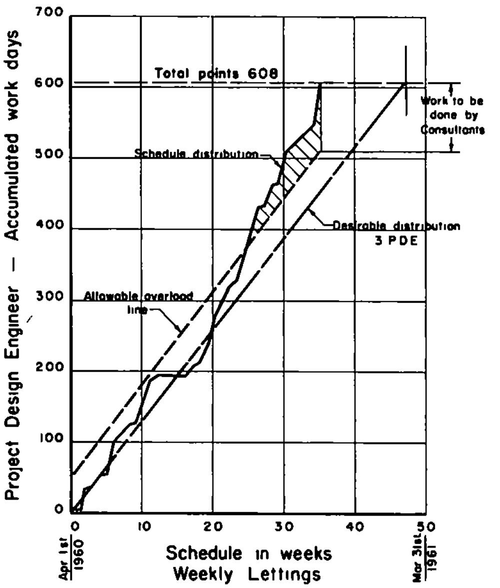


Figure 8. Work-time graph, 1960-1961 program, central region. Districts: Hamilton, Toronto and Port Hope.

It is also not practical to provide enough staff to do the entire program and meet the schedule, because staff requirements vary, not only from year to year, but during different periods of the year. For this reason the number of project design engineer groups should be provided that will give a productive ability line, consistently below the scheduled production line, purposely allowing the excess work to be assigned to consulting engineers.

The fact must be considered that the time required of the project engineer will be, for the most part, approximately as follows: field inspection, 35 percent; writing reports, 20 percent; liaison with outside departments or municipalities, about 15 percent; reviewing contracts under construction, 10 percent; and other than production functions, 5 percent. This leaves only some 15 percent of his time available for administration or advisory duties in the regional design office. The groups of estimators under his direction must have supervision regardless of whether the project design engineer is in or out of the office. The provision of a senior estimating supervisor, directly under the project design engineer, is, therefore, mandatory.

Similarly, the field staff also requires supervision. In this case, however, the amount of administrative and office work for one project design engineer would not warrant the allotment of a senior field staff supervisor to each project design engineer. One senior field staff supervisor should be adequate for each region.

The duties of the project design engineer include the relocation of utilities and processing of property requests. These jobs are of a nature that requires more attention than the project design engineer can devote to them without seriously disrupting his other work. Furthermore, the senior project design engineer must become involved in this processing of utility and property requests through the regional office. It seems reasonable that a utilities and right-of-way man be established directly under the senior project engineer to look after these functions.

The control and production of each regional office will require that a constant record be kept of the progress of all projects through the regional office. It is essential that the senior project design engineer be able to answer, on a moment's notice, queries on design progress and expected completion date for all projects under his jurisdiction. Inasmuch as recording progress on projects is more or less of a clerical function, scheduling control may be assigned to the present clerical supervisor. This duty of maintaining a constant record of progress on projects will be additional to his present and normal duties of supervising stenographic and clerical staff.

Summary Recommendations and Conclusions

As a result of the study of the problems of staffing and organizing the road design office it is recommended that:

1. The road design office be de-centralized to the regions proposed, and that staff be assigned to head office and the regions according to the organization chart shown in Figure 9. This chart has been prepared from application of the point evaluation system

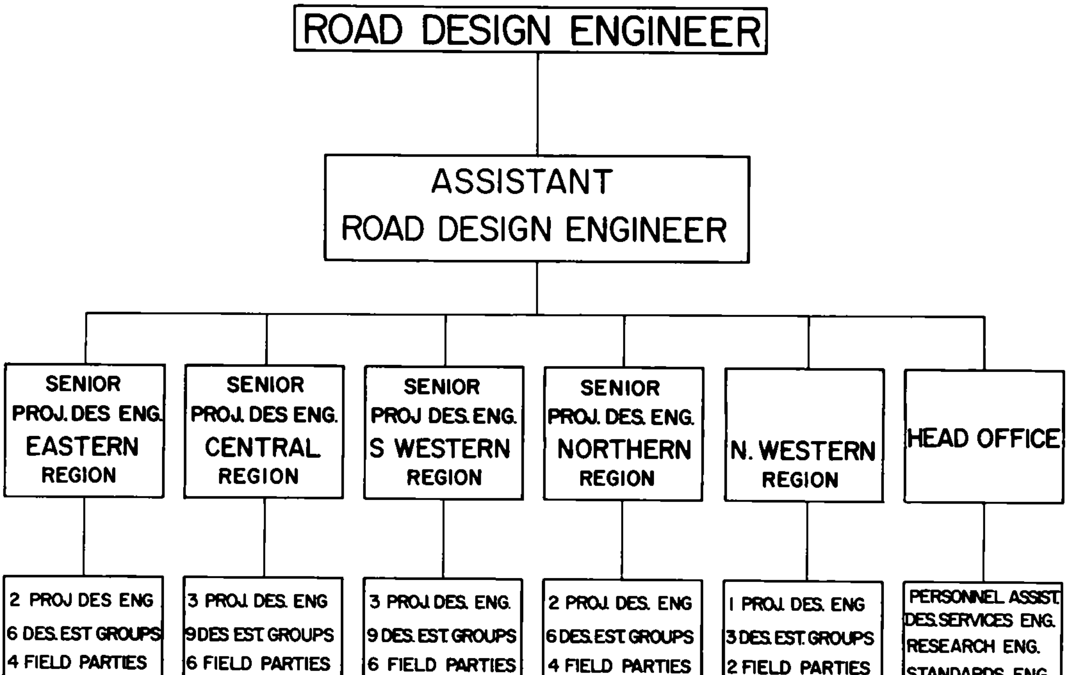


Figure 9.

to the 1960-61 program. With the adoption of the 20-year plan this year's program should be typical of the programs for the years to follow.

2. The project point evaluation system to be adopted by the road design office for allotting work to road design staff, and assigning work to consultant engineers. The project point evaluatión system appears to be such a useful and versatile method of control of the work program that it may also prove useful in the programming, scheduling, planning, location and bridge sections. Adoption to other sections, of course, will require modifications; however, the basic principles and methods seem applicable.

3. Of the total 1960-61 program, road design staff as proposed (11 project engineers) will carry approximately 1,900 points of work, which is roughly 76 percent of the total program.

4. Consulting engineers will provide for approximately 600 points of work, or 24 percent of the program.

5. Additional projects may, in some cases, be added to the 1960-61 program. The scheduling of any additional work projects must be carefully considered to avoid disruption of the road design office work output. If an additional project causes the schedule distribution line so to rise above the allowable, then the project should be given to consultants.

6. The work to be given out to consultants must be carefully selected so that it will produce the desired effect of relieving the work load on the road design staff at the appropriate time.

7. Work may be assigned to consultant engineers on the schedule prior to the actual overload period, which will give the same effect as assigning work on the schedule during overload period.

8. Work given out to consultants should be on the basis that they carry out all functions of the road design office work from and including the project design engineers' level down. Consultants work should be supervised directly by the senior project design engineer of the appropriate region.

The engineer in charge of a highway design office is constantly faced with the problems of gaging and organizing his staff in such a way that its production will coincide with a given schedule of highway construction. This schedule rarely gives much consideration to the fact that the design office, with a more or less constant staff, cannot cope with erratic increases of production. The point evaluation system seems to give the design engineer an advance evaluation and appreciation of the work load, which will allow him to organize and make the most efficient use of his staff, and to prepare for overloads of work in advance.

EVALUATION OF DE-CENTRALIZATION AND USE OF THE POINT SYSTEM OVER THE PAST TWO PROGRAMS

In April 1959, the report on "Road Design Office Organization" was accepted and steps were taken to implement the recommendations of the report. De-centralization was carried out to completion by the fall of 1959. Staff was re-distributed and the road design office organization modified to comply reasonably with that formulated on the basis of the project point evaluation system.

De-Centralization

De-centralization has proved successful in providing the benefits originally expected. The most significant of these are the saving in time formerly lost in traveling, and the more intimate contact the project design engineers and regional personnel have with their work and with the local municipal, utility, and drainage authorities.

One unexpected benefit to the department is the lively spirit of competition that has developed between the regions to out-do each other in producing the best quality of work. This competition has resulted in a noticeable general up-grading in quality and workmanship.

The Project Point Evaluation System

Since the establishing of the point values for the different categories of highway contracts, the preparation of an additional 80 projects from inception to completion within the road design office have been observed. Time records and observations indicated that the time required to prepare a project is not a direct line function of the mileage or size of the job, as originally assumed. Instead, because of certain operations which require the same length of time regardless of size, the number of points for any one project are composed of a minimum constant number of points plus an additional number of points per mile.

With the realization of the benefits of a planned program according to the needs study, the road design office now receives the schedule of proposed construction at least two years in advance of tender award. Although the budget is still voted annually and could affect the immediate final program, the projects are in the order of priority and project preparation is affected very little. With an even schedule of work to the design office, the former April 1st starting date ceases to be significant.

The method of plotting the work-time graph has been altered to take this into consideration. The graph for any one project commences at the scheduled date when the planning, materials and research, and location information is available, and terminates on the date scheduled for road design completion. This period has now been established as 8 months in length. The line of required production is then calculated from the summation of productive effort required on all projects under preparation at the time under consideration.

Present Point Evaluation and Use

The point values as now used are given in Table 1.

TABLE 1

WORK PROJECT POINT EVALUATION

Type of Work	Project Design Engineers			Estimators	
	Wk. Days	Basic Wk. Days	Wk. Days per Mile	Gp Wk Days	Gp. Wk. Days per Mile
Structure	4	—	—	5	—
Structure & approaches	5	—	—	9	—
Structure & approaches with Railway Board Estimate	6	—	—	14	—
Minor interchange (complete, incl. structure & 2 quadrants)	7	—	—	15	—
Minor interchange (incl grading & structure only & 2 quadrants)	6	—	—	13	—
Reconstruct minor interchange (complete incl. structure & 2 quadrants)	9	—	—	18	—
Major interchange (incl grading, & structure only & 4 quadrants)	7	—	—	18	—
Major interchange (complete incl. structure & 4 quadrants)	8	—	—	25	—
Reconstruct major interchange (complete incl. structure & 4 quadrants)	13	—	—	30	—
G.D & G.B C.					
2- or 4-lane rural	—	6	1	—	6
G.D.					
Divided hwy rural	—	6	1	—	8
G, D, G, B. & H. M.					
2- or 4-lane rural	—	6	1	—	7
Reconstruct divided highway rural	—	6	1	—	8
Reconstruct 2- or 4-lane urban	—	8	3	—	30
Reconstruct divided highway urban	—	8	3	—	25
G.B.C & H.M					
2- or 4-lane rural	—	4	½	—	3
Divided hwy rural	—	4	½	—	4
Hot Mix					
2- or 4-lane rural	—	4	¼	—	2½
Divided hwy rural	—	4	¼	—	3
2- or 4-lane urban	—	4	1	—	4
Divided hwy urban	—	4	1	—	2½

TABLE 2

Type of Work	Project Design Engineers: Basic Wk. Days	Project Design Engineers: Work Days	Estimators: Group Wk. Days
Structure		4	5
G. D. GB. H. M. (rural)		4	28
G. D. GB. H. M. (urban)	8	3	30
	8 +	11 = 19 Wk. Days	63 Gp. Wk. Days

A typical project would be a four-lane highway with work consisting of grading, drainage, granular base, hot-mix paving and structure. The project is 4.5 miles long with 4 miles rural and 0.5 miles urban. Pointing is as given in Table 2.

TABLE 3

WORK PROJECT POINT EVALUATION, TORONTO DISTRICT NO 6, 1960-61 PROGRAM (OCT 15/60) REV.

Schedule No.	Highway No	Type of Work	Length (mi) Total	Length (mi) Rural	Length (mi) Urban	Point Evaluation P. D. E Work Days
1960						
1	401	S	—	—	—	4
2	QEW	S, GD, GB, P.	1 1	—	1 1	33
4	401	S	—	—	—	5
6	47	GD, GB	2 0	1 0	1.0	12
12	QEW	Paving	9 6	9 6	—	7
15	400	GD, GB, P S.	—	—	—	9
17	11	GD, GB, P.	1.0	—	1 0	11
19	401	GD, GB, P	1 2	—	1.2	12
21	2	GD, GB, P	5.5	3.0	2 5	18
23	401	Structure	1 0	—	1.0	13
23	2-401	GD, GB, P.S.	1 0	—	1 0	15
25	5	GD, GB, P S	—	—	—	14
26	48	S	—	—	—	4
26	9	S	—	—	—	6
28	48	S	—	—	—	4
33	400	S	—	—	—	6
34	401	G, Paving S.	—	2.5	—	14
45	9	GD, GB	10.0	10 0	—	16
45	9	S	—	—	—	4
46	5	GD, GB, P.	4 5	2.5	2.0	18
47	5	GD, GB	5.3	2 0	3 3	20
50	48	GD, GB, P	6.1	4	2 1	18
1961						
8	400	S	—	—	—	6
10	27	GD, GB, P	1	1	—	7
11	401	S	—	—	—	9
11	401	S	—	—	—	4
11	401	GD, GB, P.	3 5	—	3.5	19
11	401	S	—	—	—	4
11	401	S	—	—	—	4
12	50	GD, GB, P.	5.0	5.0	—	11
12	50	GD, GB, P.	4 0	3.0	1.0	14
12	50	S	—	—	—	4
12	401	S	—	—	—	4
12	401	S	—	—	—	13
12	401	S	—	—	—	4
13	401	S	—	—	—	4
13	401	S	—	—	—	13
13	401	S	—	—	—	4
13	401	S	—	—	—	13
13	401	S	—	—	—	4
15	7	GD, GB, P	—	—	—	7
17	10	GD, GB, P	4.2	3 2	1 0	14
17	10	S	—	—	—	6
19	11	GD, GB, P	7 0	6.0	1 0	17
19	401	GD, GB, P.	—	—	—	9
20	7	GD, GB, P.	4.7	4.7	—	11
20	7	GD, GB, P.	1.0	1.0	—	7

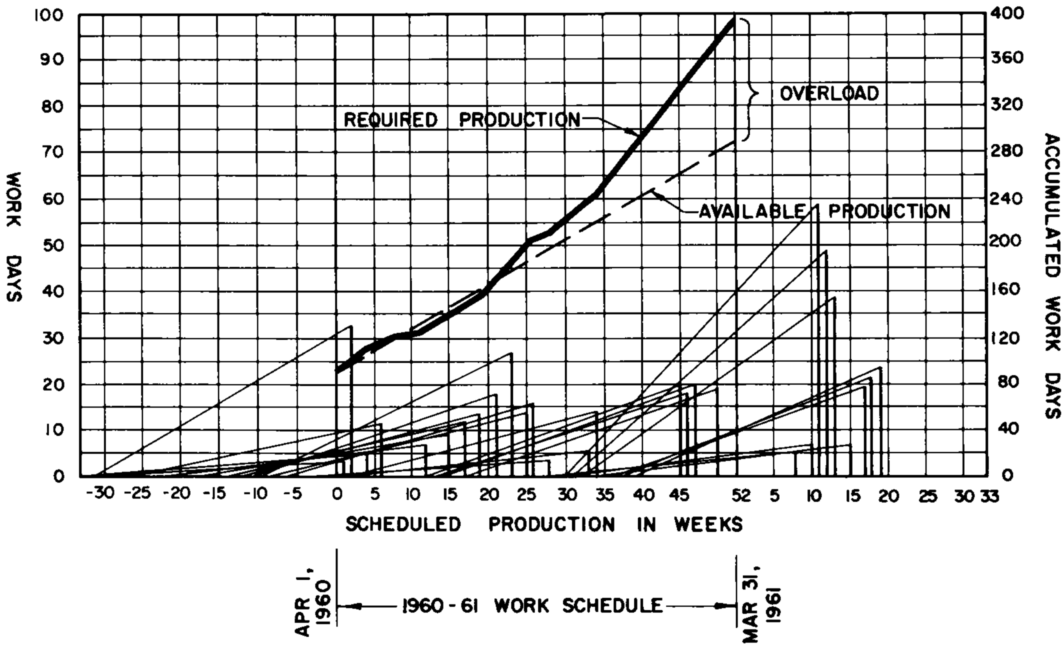


Figure 10. Work-time graph, 1960-1961 program, central region, one project design engineer, Toronto District.

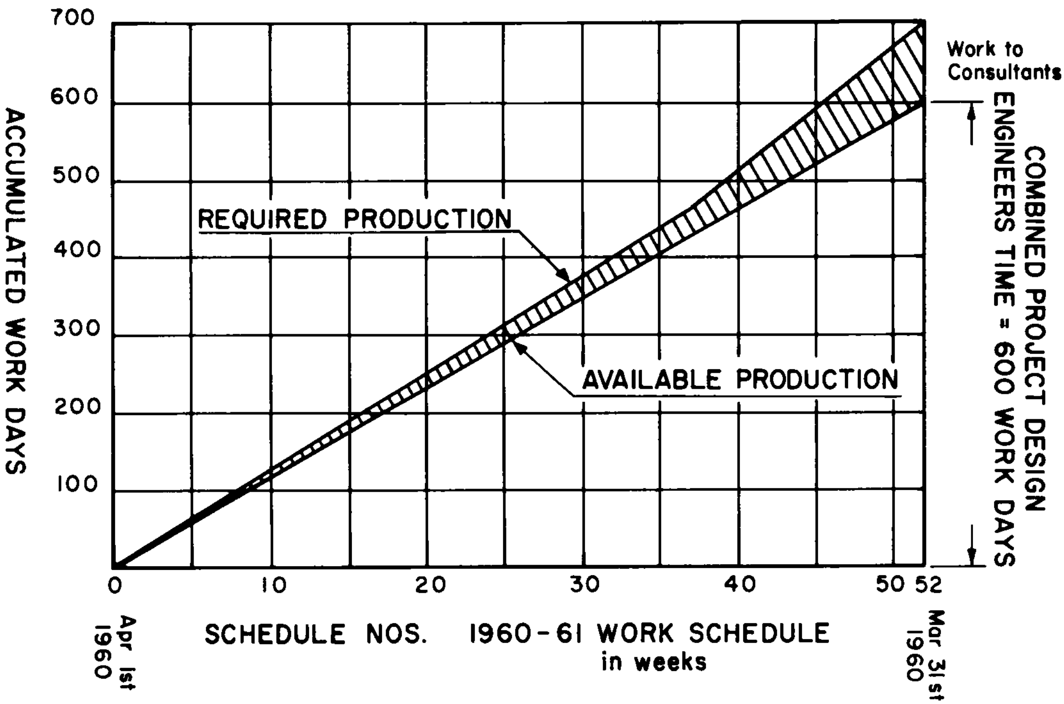


Figure 11. Combined work-time graph, project design engineers, central region.

Project Engineer's Work Load

To evaluate the work load for any one project design engineer, all projects assigned to him must be assessed (Table 3).

From these calculated work-load values (Table 3) the separate projects may be plotted against time available, in their scheduled position on the program. From summation of the project points a work-time curve may also be plotted (Fig. 10) that shows the production required to meet the schedule for the fiscal year starting April 1, 1960 and ending March 31, 1961. The project design engineer has only 200 days working time over this same period. Superimposing his available production line on the required production line, shows where he will fall behind on the program. The work-time graph in Figure 10 indicates that he is overloaded with approximately 100 points of work, between the 20th and 52nd week of the fiscal year.

If similar charts are plotted for the remaining project design engineers in the central region and combined as shown in Figure 11, a graph can be obtained showing required production as against available production for the central region. This graph illustrates an overload of 100 points of work throughout the year, and therefore, 100 points of work must be assigned to consultant engineers to meet the schedule. This work will be chosen by review of the separate project design engineers' work-time graphs and the projects individually selected to drop the required production line within the capacity of the road design staff.

Trends in Highway Engineering Employment: 1960 Inventory of State Highway Engineering Employment

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● IN 1956 the Highway Research Board conducted a census of State highway department employees to obtain the number of engineers and engineering aids (technicians) employed in each State for the year 1956 (1).

It was felt at that time that this information could be used as a tool to (a) determine engineering requirements for construction and maintenance; (b) relate the requirements to an expanded construction and maintenance program; (c) determine the number of aids required in terms of those classified as engineers; and (d) determine the best use of engineers.

The 1956 study provided more information than had been available previously; and in spite of some shortcomings, it was probably the first complete count of State highway engineering manpower ever made that could be considered reasonably accurate.

In 1960 a census of highway engineering employment was undertaken by the Bureau of Public Roads to develop trends in the number of employees, educational and registration level, turnover of personnel, training programs, and engineering manpower needs. Present plans call for a periodic survey of State highway department manpower, although in somewhat less detail. These data will provide a solid base for further study into manpower needs and the use of personnel.

This paper does not present all of the data which has been reported by the States in this survey; it summarizes only that portion of the information pertaining to the number and kind of persons employed. Subsequent reports will summarize the remainder of the information supplied by the States.

This 1960 study is considerably more comprehensive than the 1956 Highway Research Board survey, in that not only were more questions asked, but also far more detail was requested from the States. For example, a complete count of all State highway department personnel was obtained; previously, only engineering manpower was covered. In addition, the present study includes information from Alaska and Hawaii which was not included in the original study. Although some States employ convicts in highway work, they are not included in this study.

In a few instances it was necessary to make estimates to obtain total figures. Some States did not choose to supply certain information or declined to give estimates where figures were not available. Where estimates appear in the tables they are in parentheses.

TOTAL EMPLOYEES

As given in Table 1, the 50 States and the District of Columbia reported a total of 204,580 people engaged in State highway activities as of January 1960. Of this total, 67,724 or nearly one-third were engineering personnel. Among the States, however, this percentage varies from 14.8 percent to almost 90 percent (Table 2).

In addition to the figures just quoted, Table 3 indicates that almost 19,000 people were employed by the State highway departments on a part-time or temporary basis as of July 15, 1959. This total includes 195 engineers and 8,565 aids (technicians) so that more than one-half of the temporary help were non-engineering employees. Five States did not report employment of any temporary people during 1959.

TABLE 1

STATE HIGHWAY DEPARTMENT EMPLOYMENT AS OF JANUARY 1960

State	State Highway Department Personnel					Equivalent Consultant Engineering Effort			Total Pers Equiv
	Engineering Personnel								
	Engr	Aids (Tech)	Total	Other Employees	Total	Engr	Aids (Tech)	Total	
Ala	472	1,204	1,676	1,798	3,474	35	55	90	3,564
Alaska	11	13	24	27	51	—	—	—	51
Ariz	88	1,270	1,358	388	1,746	43	52	95	1,841
Ark	141	477	618	2,211	2,829	6	17	23	2,852
Calif	2,419	3,870	6,289	6,192	12,481	—	—	—	12,481
Colo	330	415	745	1,064	1,809	—	—	—[1]	1,809
Conn	492	588	1,080	3,410	4,490	300	—	300	4,790
Del	61	274	335	788	1,123	20	200	220	1,343
Fla	534	1,578	2,112	(3,388)[2]	(5,500)[2]	—	—	—	(5,500)[2]
Ga	811	870	1,681	3,389	5,070	23	20	43	5,113
Hawaii	114	226	340	386	726	7	8	15	741
Idaho	155	61	216	1,239	1,455	2	28	30	1,485
Ill	1,230	921	2,151	3,349	5,500	226	255	481[3]	5,981
Ind	456	329	785	3,838	4,623	180	54	234	4,857
Iowa	311	702	1,013	2,187	3,200	39	78	117	3,317
Kan	472	512	984	2,530	3,514	17	8	25	3,539
Ky	579	1,441	2,020	5,499	7,519	—	—	—	7,519
La	398	1,383	1,781	4,960	6,741	96	193	289	7,030
Me	222	103	325	1,805	2,130	35	30	65	2,195
Md	483	626	1,109	2,164	3,273	—	—	—[1]	3,273
Mass	873	751	1,624	672	2,296	132	266	398	2,694
Mich	806	976	1,782	2,330	4,112	224	138	362	4,474
Minn	459	1,087	1,546	2,912	4,458	80	56	136	4,594
Miss	214	879	1,093	1,524	2,617	—	—	—[4]	2,617
Mo	850	896	1,746	3,367	5,113	—	—	—[1]	5,113
Mont	275	303	578	1,191	1,769	—	—	—	1,769
Neb	247	1,522	1,769	217	1,986	10	55	65	2,051
Nev	174	161	335	621	956	17	14	31	987
N H	290	75	365	933	1,298	17	18	35	1,333
N J	528	353	881	2,867	3,748	273	410	683[5]	4,431
N Mex	43	613	656	1,407	2,063	—	—	—[1]	2,063
N Y	1,423	1,502	2,925	7,298	10,223	505	740	1,245	11,468
N C	553	788	1,341	6,569	7,910	4	—	4	7,914
N D	150	207	357	655	1,012	5	5	10	1,022
Ohio	694	2,483	3,177	5,548	8,725	68	69	137	8,862
Okla	79	540	619	1,898	2,517	40	20	60	2,577
Ore	516	454	970	2,339	3,309	—	—	—	3,309
Pa	796	2,415	3,211	10,832	14,043	239	358	597	14,640
R I	89	182	271	705	976	25	6	31	1,007
S C	205	956	1,161	3,839	5,000	—	—	—	5,000
S D	125	400	525	906	1,431	100	50	150	1,581
Tenn	355	1,735	2,090	3,122	5,212	150	109	259	5,471
Tex	1,196	3,998	5,194	9,944	15,138	(3)[2]	—	3	15,141
Utah	161	416	577	914	1,491	175	—	175	1,666
Vt	244	89	333	648	981	44	38	82	1,063
Va	570	1,325	1,895	5,751	7,646	25	75	100	7,746
Wash	907	451	1,358	1,716	3,074	—	—	—	3,074
W Va	146	618	764	3,939	4,703	265	133	398	5,101
Wis	487	470	957	360	1,317	107	—	107	1,424
Wyo	167	275	442	570	1,012	—	—	—	1,012
D C	107	433	540	650	1,190	270	20	290	1,480
Total	23,508	44,216	67,724	136,856	204,580	3,807	3,578	7,385	211,965
Total 48 States and D C	23,383	43,977	67,360	136,443	203,803	3,800	3,570	7,370	211,173

[1] States reported that this information was not available
[2] Estimates for States that did not furnish data
[3] Does not include consultant work on Chicago Expressway during 1959
[4] Mississippi reported a total of less than one
[5] New Jersey estimate was for Fiscal Year 1959

It is, of course, difficult to determine the total productive effort supplied to the highway departments by temporary and part-time employees because how long they worked, their educational background, or just what type of work they were doing is not available in convenient form. However, many of these people could be presumed to have been engaged in maintenance operations, in summer traffic surveys and traffic counts, and in route location surveys.

In some States the number of temporary people employed is relatively insignificant. However, in several States temporary and part-time employees are nearly one-half as numerous as full-time employees.

ENGINEERING EMPLOYMENT

Tables 4 and 5 show that in January 1960 State highway departments, including the District of Columbia, employed 23,508 engineers and 44,216 engineering aids (technicians) for a total of 67,724 engineering employees. The 48 contiguous States plus the District of Columbia reported 23,383 engineers and 43,977 aids or a total of 67,360 engineering personnel. This represents a 13.8 percent increase in engineers and a 69.7

percent increase in the aid category since March 1956. Total engineering employees have increased 45.0 percent. This was not, however, the total engineering effort expended by State highway departments. Consulting firm personnel supplied approximately 7,400 man-years of engineering effort to assist State highway engineers (Table 1). Of this total figure, 3,800 man-years were for engineers and 3,600 were for aids or technicians.

Capital outlay by the State highway departments of the 48 States (excluding toll facilities) rose from over $2,200 million in 1955 to more than $4,800 million in 1959, or an increase of almost 120.0 percent. This increase in dollar expenditures was accompanied by only a 52.7 percent increase in total engineering man-years, including the work of consultants. In all probability the use of electrical accounting and data processing machines, aerial surveying techniques, simplified procedures, and the like contributed to increased efficiency; but it is likely that much additional productive effort was gained by the more effective use of engineering manpower.

Table 6 summarizes the number of engineers and aids employed in January 1960 as compared with March 1956. A particularly interesting figure is the ratio of aids to engineers. Although it may be too early to tell what this ratio will be in the future, the data indicate that the ratio is rising. On the average, engineers are supervising 1.88 aids or technicians compared with 1.26 in 1956. Although this seems to indicate a more favorable use of engineers, some experts in the field of engineering productivity feel that the average engineer can and should effectively supervise five or six aids or technicians to get the maximum benefit from the engineer's education and ability. The Nebraska Highway Department showed the greatest gain in the ratio of aids to engineers from 0.93 to 6.16. About one-third of the States, however, ran contrary to the national trend; Idaho was the most extreme example. The ratio of aids to engineers dropped from 3.26 in March 1956 to 0.39 in January 1960. In view of the different classification plans in use by the several States, it is difficult to determine how much of the change in ratio is due to changes in classification and definition.

As was the case in 1956, the ratio of aids to engineers showed wide variations among the States. In March 1956 the variation was from 10.83 in New Mexico to 0.14 in Illinois, and in January 1960 the ratio was from 14.43 in Arizona to 0.26 in New Hampshire. The reasons for these wide variations are not readily apparent. Comparing the States by regions, however, shows that a regional pattern exists, although to a considerably less extent than in 1956 (Table 7). In the earlier report the New England, Middle Atlantic, East North Central, and Pacific regions each employed more engineers than aids. This is no longer true except in the New England region. However, these same regions all employ considerably less than two aids per engineer, whereas all other regions employ more than two. The variations among the regions, however, are not nearly as great as are those among the States.

In analyzing the various regions there were some States which fell somewhat outside the pattern for their region. In the New England region, for example, which employs more engineers than aids; Rhode

TABLE 2

PERCENTAGE OF ENGINEERING EMPLOYEES IN STATE HIGHWAY DEPARTMENTS, JANUARY 1960

State	Engineers	Aids (Technicians)	Total
Ala	13 6	34 6	48 2
Alaska	21 6	25 5	47 1
Ariz	5 1	72 7	77 8
Ark	5 0	16 8	21 8
Calif	19 4	31 0	50 4
Colo	18 3	22 9	41 2
Conn	11 0	13 1	24 1
Del	5 4	24 4	29 8
Fla	9 7	28 7	38 4
Ga	16 0	17 2	33 2
Hawaii	15 7	31 1	46 8
Idaho	10 6	4 2	14 8
Ill	22 4	16 7	39 1
Ind	9 9	7 1	17 0
Iowa	9 7	22 0	31 7
Kan	13 4	14 6	28 0
Ky	7 7	19 2	26 9
La	5 9	20 5	26 4
Me	10 4	4 9	15 3
Md	14 8	19 1	33 9
Mass	38 0	32 7	70 7
Mich	19 6	23 7	43 3
Minn	10 3	24 4	34 7
Miss	8 2	33 6	41 8
Mo	16 6	17 5	34 1
Mont	15 6	17 1	32 7
Neb	12 5	76 6	89 1
Nev	18 2	16 8	35 0
N H	22 3	5 8	28 1
N J	14 1	9 4	23 5
N Mex	2 1	29 7	31 8
N Y	13 9	14 7	28 6
N C	7 0	10 0	17 0
N D	14 8	20 5	35 3
Ohio	8 0	28 4	36 4
Okla	3 1	21 5	24 6
Ore	15 6	13 7	29 3
Pa	5 7	17 2	22 9
R I	9 1	18 7	27 8
S C	4 1	19 1	23 2
S D	8 7	28 0	36 7
Tenn	6 8	33 3	40 1
Tex	7 9	26 4	34 3
Utah	10 8	27 9	38 7
Vt	24 9	9 0	33 9
Va	7 5	17 3	24 8
Wash	29 5	14 7	44 2
W Va	3 1	13 1	16 2
Wis	37 0	35 7	72 7
Wyo	16 5	27 2	43 7
D C	9 0	36 4	45 4
Total	11 5	21 6	33 1
Total 48 States and D C	11 5	21 6	33 1

TABLE 3

STATE HIGHWAY DEPARTMENT PART-TIME AND TEMPORARY EMPLOYMENT, JULY 15, 1959 AND ESTIMATED JULY 15, 1960

State	Engineers		Aids (Tech.)		Other		Total	
	1959	1960	1959	1960	1959	1960	1959	1960
Ala.	1	—	19	25	—	—	20	25
Alaska	—	—	—	—	—	—	—	—
Ariz.	—	—	—	—	135	135	135	135
Ark.	—	—	74	74	82	82	156	156
Calif.	4	5	302	300	49	45	355	350
Colo.	—	—	45	12	241	241	286	253
Conn.	—	—	82	—	212	—	294	—
Del.	—	—	60	60	47	35	107	95
Fla.	—	—	—	—	—	—	—	—
Ga.	50	50	25	25	—	—	75	75
Hawaii	7	5	15	20	3	5	25	30
Idaho	—	—	207	240	56	80	263	320
Ill.	16	11	515	492	1,922	2,027	2,453	2,530
Ind.	1	2	86	85	187	208	274	295
Iowa	2	2	125	75	250	200	377	277
Kan.	3	—	200	—	100	100	303	100
Ken.	1	—	103	—	296	—	400	—
La.	1	1	150	150	70	70	221	221
Me.	3	3	79	79	878	878	960	960
Md.	—	—	59	60	100	100	159	160
Mass.	—	—	—	—	—	—	—	—
Mich.	3	3	324	400	—	—	327	403
Minn.	—	—	143	140	1,137	1,140	1,280	1,280
Miss.	14	20	154	110	456	556	624	686
Mo.	3	2	320	300	600	600	923	902
Mont.	12	12	201	200	85	85	298	297
Neb.	7	7	169	170	4	10	180	187
Nev.	—	—	46	50	18	20	64	70
N. H.	5	5	44	44	—	—	49	49
N. J.	4	5	72	75	22	20	98	100
N. Mex.	—	—	68	68	54	54	122	122
N. Y.	13	13	291	265	66	69	370	347
N. C.	1	1	144	137	704	686	849	824
N. D.	2	2	575	500	60	60	637	562
Ohio	10	16	330	362	416	436	756	814
Okla.[1]	—	—	—	—	—	—	—	—
Ore.	—	—	155	150	—	—	155	150
Pa.	5	8	674	692	49	52	728	752
R. I.	—	—	20	20	—	—	20	20
S. C.	6	6	250	250	300	300	556	556
S. D.	—	—	200	200	—	—	200	200
Tenn.	3	4	183	175	183	180	369	359
Tex.	—	—	922	922	—	—	922	922
Utah	—	—	200	225	150	175	350	400
Vt.	3	3	126	126	340	340	469	469
Va.	—	—	60	60	660	540	720	600
Wash.	10	5	43	21	10	5	63	31
W. Va.	—	—	—	—	—	—	—	—
Wis.	5	5	705	600	12	15	722	620
Wyo.	—	—	—	—	186	200	186	200
D. C.	—	—	—	—	—	—	—	—
Total	195	196	8,565	7,959	10,140	9,749	18,900	17,904
Total: 48 States and D. C.	188	191	8,550	7,939	10,137	9,744	18,875	17,874

[1] Oklahoma reported that this information was not available.

Island employs twice as many aids as they do engineers. In the Middle Atlantic region, New Jersey has considerably more engineers than aids; but this is not true for New York and Pennsylvania. In the Mountain region the ratios vary from 0.39 in Idaho to 14.43 in Arizona. Generally speaking, as was true in 1956, highly populated regions tend to employ a greater percentage of engineers in relation to aids than do less populated regions; but there are some States within highly populated regions that do not follow this pattern.

MAINTENANCE EMPLOYEES

Information pertaining to maintenance employees is given in Table 8. Of the total of nearly 68,000 engineering employees, the States reported that approximately 6 percent

TABLE 4

ENGINEERS IN STATE HIGHWAY DEPARTMENTS AS OF JANUARY 1960

	Civ. Engr. Col. Grad.			Non-Civ. Engr. Col. Grad.			Non-Engr. Col. Grad.			No Col. Degree			
State	Reg'd. Civ. Engr.	Reg'd. Non-Civ. Engr.	Not Reg'd.	Reg'd. Civ. Engr.	Reg'd. Non-Civ. Engr.	Not Reg'd.	Reg'd Civ Engr.	Reg'd. Non-Civ. Engr	Not Reg'd.	Reg'd. Civ. Engr.	Reg'd. Non-Civ. Engr.	Not Reg'd.	Total Engr.
Ala.	71	—	58	5	2	11	—	—	18	307	—	—	472
Alaska	1	—	3	—	—	—	—	—	—	3	—	4	11
Ariz.	48	—	14	7	—	—	—	3	—	16	—	—	88
Ark.	36	—	43	1	2	1	4	—	2	41	—	11	141
Calif.	599	1	819	78	10	169	27	2	193	314	2	205	2,419
Colo.	13	—	15	11	—	46	—	—	12	13	—	220	330
Conn.	50	—	104	2	3	16	3	2	37	9	3	263	492
Del.	22	—	21	—	—	—	—	—	—	7	—	11	61
Fla.	56	9	56	9	—	13	—	—	8	46	10	327	534
Ga.	50	—	81	11	—	22	5	—	42	80	—	520	811
Hawaii	33	—	58	1	—	—	—	—	1	3	—	18	114
Idaho	64	—	32	—	1	2	—	—	7	19	—	30	155
Ill.[1]	379	—	511	55	—	90	12	—	23	106	—	54	1,230
Ind.	248	—	164	2	4	—	13	—	—	25	—	—	456
Iowa	144	—	78	48	2	—	9	—	—	30	—	—	311
Kan.	207	—	85	5	—	2	3	—	—	10	—	160	472
Ky.	78	—	115	4	5	2	3	1	35	137	—	199	579
La	175	—	—	14	23	—	3	—	—	183	—	—	398
Me.	84	—	53	2	3	—	1	—	10	16	—	53	222
Md.	11	—	21	1	—	6	1	—	26	38	9	370	483
Mass.	259	—	21	18	—	6	16	—	18	250	—	285	873
Mich.	209	—	332	9	6	26	7	1	17	20	—	179	806
Minn.	94	—	105	13	2	8	9	—	2	220	—	6	459
Miss.	85	6	78	10	5	4	1	—	—	22	—	3	214
Mo.	148	—	205	—	28	27	7	—	72	97	—	266	850
Mont.	30	—	9	11	—	6	—	—	—	66	—	153	275
Neb.	44	—	9	21	1	10	6	—	9	68	—	79	247
Nev.	10	—	5	10	—	4	—	—	17	21	2	105	174
N.H.	47	—	97	—	—	—	—	—	—	19	—	127	290
N.J.	41	—	101	2	2	18	—	—	26	50	—	288	528
N. Mex.	18	—	—	1	—	—	1	—	—	23	—	—	43
N.Y.	258	—	261	54	—	48	8	—	47	99	—	648	1,423
N.C.	31	—	158	—	—	11	—	—	21	9	5	318	553
N.D.	30	8	31	3	7	3	2	—	6	15	—	45	150
Ohio	411	5	59	13	18	5	19	—	27	117	5	15	694
Okla.	21	—	4	2	—	—	2	—	2	21	—	27	79
Ore.	67	—	69	18	—	21	—	—	48	31	—	262	516
Pa.	65	3	152	4	2	6	5	1	56	56	3	443	796
R.I.	16	—	4	1	—	2	2	—	3	12	12	37	89
S.C.	31	4	72	—	—	9	—	—	31	5	2	51	205
S.D.	13	—	44	—	—	17	—	—	10	10	—	31	125
Tenn.	20	—	67	—	—	12	2	—	25	50	—	179	355
Tex.	591	—	240	68	—	60	—	—	—	237	—	—	1,196
Utah	25	—	32	6	—	9	—	—	20	9	—	60	161
Vt	32	—	82	2	2	11	3	—	20	24	1	67	244
Va.	40	—	91	1	—	9	—	—	10	42	—	377	570
Wash.	93	—	119	10	5	12	11	—	74	56	2	525	907
W. Va.	30	—	38	—	14	2	—	—	—	62	—	—	146
Wis.	130	—	239	9	—	4	5	—	4	34	—	62	487
Wyo.	42	—	42	—	—	—	7	—	7	33	—	36	167
D.C.	15	—	52	—	1	11	—	—	7	3	1	17	107
Total	5,315	36	5,149	542	148	741	197	10	993	3,184	57	7,136	23,508
Total 48 States and D.C.	5,281	36	5,088	541	148	741	197	10	992	3,178	57	7,114	23,383

[1] Illinois does not register civil engineers separately from other engineers.

TABLE 5

ENGINEERING AIDS (TECHNICIANS) IN STATE HIGHWAY DEPARTMENTS AS OF JANUARY 1960

State	Civ. Engr. Col. Grad.			Non-Civ Engr. Col. Grad.			Non-Engr. Col. Grad.			No Col. Grad.			Total Engr. Aids. (Tech.)
	Reg'd. Civ. Engr	Reg'd. Non-Civ. Engr.	Not Reg'd	Reg'd. Civ Engr.	Reg'd. Non-Civ. Engr	Not Reg'd.	Reg'd. Civ Engr.	Reg'd. Non-Civ Engr	Not Reg'd	Reg'd. Civ Engr.	Reg'd. Non-Civ. Engr.	Not Reg'd.	
Ala.	11	—	—	—	—	—	—	—	—	—	—	1,193	1,204
Alaska	—	—	1	—	—	—	—	—	1	—	—	11	13
Ariz.	—	—	—	—	—	—	—	—	—	—	—	1,270	1,270
Ark.	—	—	—	—	—	—	—	—	3	—	—	474	477
Calif.	—	—	—	1	—	—	—	—	—	37	4	3,828	3,870
Colo.	1	—	1	—	—	6	—	—	1	2	—	404	415
Conn.	—	—	4	—	6	9	—	2	22	1	—	544	588
Del.	1	—	—	—	—	3	—	—	—	1	—	269	274
Fla	—	—	4	—	—	—	—	—	—	3	—	1,571	1,578
Ga.	—	—	—	—	—	—	—	—	—	—	—	870	870
Hawaii	—	—	5	—	—	—	—	—	5	—	—	216	226
Idaho	1	—	—	—	—	7	—	—	9	1	—	43	61
Ill.[1]	2	—	2	3	—	12	8	—	100	9	—	785	921
Ind.	—	—	—	—	—	—	—	—	2	—	—	327	329
Iowa	—	—	—	—	—	3	—	—	98	—	—	601	702
Kan.	—	—	—	—	—	—	—	—	—	—	—	512	512
Ky	—	—	—	—	—	—	—	—	17	9	—	1,415	1,441
La[2]	—	—	—	—	—	—	—	—	—	—	—	(1,383)	1,383
Me.	—	—	—	—	—	—	—	—	—	—	—	103	103
Md.	—	—	1	—	—	—	—	—	—	—	—	626	626
Mass.	—	—	6	—	—	4	—	—	41	1	—	699	751
Mich.	—	—	—	—	—	—	—	—	—	—	—	976	976
Minn	—	—	—	—	—	6	—	—	34	10	1	1,036	1,087
Miss	—	—	13	—	—	—	—	—	49	—	—	817	879
Mo.	—	—	2	—	—	1	—	—	—	4	—	889	896
Mont.	—	—	—	—	—	—	—	—	12	—	—	291	303
Neb.	—	—	2	—	1	—	—	—	37	—	—	1,482	1,522
Nev.	—	—	—	—	—	—	—	—	—	—	—	161	161
N H	—	—	—	—	—	—	—	—	—	—	—	75	75
N.J.	—	—	—	—	—	1	—	—	5	—	—	347	353
N. Mex.	24	—	10	2	1	4	1	—	4	—	—	567	613
N.Y.	—	—	4	—	—	2	—	—	43	—	—	1,453	1,502
N C.	—	—	1	—	—	1	—	—	10	—	—	776	788
N.D.	—	—	—	—	—	—	—	—	3	—	—	204	207
Ohio	1	2	31	—	—	—	1	—	95	—	25	2,328	2,483
Okla	—	—	10	—	—	—	—	—	—	—	—	530	540
Ore.	—	—	—	—	—	—	5	—	—	—	—	449	454
Pa.	1	—	5	1	—	3	—	—	50	—	—	2,355	2,415
R.I	—	—	2	—	—	—	—	—	7	—	—	173	182
S.C.	—	—	25	—	—	7	—	—	10	—	3	911	956
S D.	—	—	—	—	—	—	—	—	14	—	—	386	400
Tenn.	—	—	—	—	—	—	—	—	30	—	—	1,705	1,735
Tex.	—	—	—	—	—	—	—	—	—	—	—	3,998	3,998
Utah	—	—	—	—	—	—	—	—	49	—	—	367	416
Vt	—	—	—	—	—	—	—	—	—	8	—	81	89
Va.	—	—	—	—	—	1	—	—	12	—	—	1,312	1,325
Wash.	—	—	—	—	—	5	—	—	12	—	—	434	451
W. Va.	—	—	—	—	—	—	—	—	—	—	—	618	618
Wis.[2]	—	—	—	—	—	—	—	—	—	—	—	(470)	470
Wyo.	—	—	—	—	—	—	—	—	17	—	—	258	275
D C.	—	—	—	—	—	10	—	—	25	—	—	398	433
Total	42	2	129	7	8	85	15	2	817	86	33	42,990	44,216
Total· 48 States and D.C.	42	2	123	7	8	85	15	2	811	86	33	42,763	43,977

[1] Illinois does not register civil engineers separately from other engineers.
[2] States reported total figure only.

were assigned to maintenance. This figure is more than two times as great as that reported for March 1, 1956. However, the earlier data are open to some question. In 1956 many of the States did not report any engineering employees assigned specifically to maintenance. Then again, in the later study some of the States reported data which apparently bear little relation to the information reported to the Highway Research Board in 1956. The current data are probably more nearly accurate and, therefore, no attempt is made to compare these figures in the two studies.

A state-by-state breakdown shows that engineering employees assigned to maintenance range from 0.1 percent of engineering personnel in Colorado to 64 percent in Nebraska. These figures by themselves are not too meaningful because the type and extent of maintenance work that is done by State forces varies widely among the States.

EDUCATIONAL LEVEL OF ENGINEERING PERSONNEL

One of the significant findings of the Highway Research Board survey in 1956 was that only 55.6 percent of all classified engineers employed were civil engineering graduates and/or registered civil engineers. In fact, 39 percent of all engineers were neither graduated nor registered in any engineering branch. The same situation prevailed at the time of the present survey, although there has been some improvement in the professional level. It can be seen from Table 4 that 61.2 percent of all engineers are now either civil engineering graduates and/or registered civil engineers; but about one-third of all engineers have neither completed a college-level engineering course, nor are they registered in any branch of engineering.

TABLE 6

STATE HIGHWAY DEPARTMENT ENGINEERING PERSONNEL

	March 1956[1]				January 1960			
State	Engr.	Aids (Tech.)	Total	Ratio of Aids (Tech.) to Engr.	Engr.	Aids (Tech.)	Total	Ratio of Aids (Tech.) to Engr.
Ala.	(521)	(785)	(1,306)	(1.51)	472	1,204	1,676	2.55
Alaska	—	—	—	—	11	13	24	1.18
Ariz	56	504	560	9.00	88	1,270	1,358	14.43
Ark	137	387	524	2.82	141	477	618	3.38
Calif.	(3,562)	(1,312)	(4,874)	(0 37)	2,419	3,870	6,289	1.60
Colo	329	438	767	1 33	330	415	745	1.26
Conn.	713	235	948	0.33	492	588	1,080	1.20
Del.	(43)	(144)	(187)	(3.35)	61	274	335	4.49
Fla.	352	1,183	1,535	3.36	534	1,578	2,112	2.96
Ga.	581	1,237	1,818	2.13	811	870	1,681	1.07
Hawaii	—	—	—	—	114	226	340	1.98
Idaho	139	453	592	3.26	155	61	216	0.39
Ill.	1,054	151	1,205	0.14	1,230	921	2,151	0.75
Ind.	360	169	529	0.47	456	329	785	0.72
Iowa	222	745	967	3.36	311	702	1,013	2.26
Kan.	310	562	872	1.81	472	512	984	1.08
Ky.	577	584	1,161	1.01	579	1,441	2,020	2.49
La.	305	924	1,229	3.03	398	1,383	1,781	3.47
Me.	170	57	227	0.34	222	103	325	0.46
Md.	390	373	763	0.96	483	626	1,109	1.30
Mass.	600	1,064	1,664	1.77	873	751	1,624	0.86
Mich.	499	800	1,299	1 60	806	976	1,782	1.21
Minn.	605	635	1,240	1.05	459	1,087	1,546	2.37
Miss.	106	590	696	5.57	214	879	1,093	4.11
Mo.	643	725	1,368	1.13	850	896	1,746	1 05
Mont.	204	283	487	1.39	275	303	578	1.10
Neb.	241	225	466	0.93	247	1,522	1,769	6.16
Nev.	(85)	(100)	(185)	(1.18)	174	161	335	0.93
N. H	215	120	335	0.56	290	75	365	0.26
N. J.	425	77	502	0.18	528	353	881	0.67
N. Mex.	48	520	568	10.83	43	613	656	14.26
N. Y.	(1,273)	(687)	(1,960)	(0.54)	1,423	1,502	2,925	1.06
N. C.	448	608	1,056	1.36	553	788	1,341	1.42
N. D.	119	45	164	0.38	150	207	357	1.38
Ohio	651	1,306	1,957	2.01	694	2,483	3,177	3.58
Okla	140	568	708	4.06	79	540	619	6.84
Ore.	509	278	787	0.55	516	454	970	0.88
Pa.	526	1,055	1,581	2.01	796	2,415	3.211	3.03
R. I	85	109	194	1.28	89	182	271	2.04
S. C.	264	445	709	1.69	205	956	1,161	4.66
S. D.	84	363	447	4 32	125	400	525	3.20
Tenn.	(225)	(250)	(475)	(1.11)	355	1,735	2,090	4.89
Tex.	913	2,755	3,668	3.02	1,196	3,998	5,194	3.34
Utah	55	99	154	1.80	161	416	577	2.58
Vt.	159	46	205	0.29	244	89	333	0.36
Va	347	765	1,112	2.20	570	1,325	1,895	2.32
Wash.	613	368	981	0.60	907	451	1,358	0.50
W. Va.	81	191	272	2.36	146	618	764	4.23
Wis.	393	349	742	0.89	487	470	957	0.97
Wyo	93	165	258	1.77	167	275	442	1.65
D. C.	81	77	158	0.95	107	433	540	4.05
Total	—	—	—	—	23,508	44,216	67,724	1.88
Total 48 States and D. C.	20,551	25,911	46,462	1.26	23,383	43,977	67,360	1.88

[1] Figures in parenthesis are estimates for States that did not furnish data. In most cases, estimates are based on data reported to Highway Research Board for July 1, 1956.

The percentages of graduate and registered civil engineers for each State are given in Table 9. Of the total classified engineers employed in all States on January 1960, about 45 percent were graduate civil engineers as compared with 39 percent for March 1956; and 39 percent were registered civil engineers in 1960 as compared with 38 percent in 1956. These figures for graduate and registered civil engineers are not additive because some civil engineers are both graduate and registered. (To obtain separate figures for graduate and registered engineers, refer to Table 4.)

Indiana reported by far the highest percentage of civil engineering graduates— more than 90 percent. At the other end of the scale, only 6.6 percent of Maryland's engineers were civil engineering graduates. States showing much improvement were Alabama, which more than tripled its percentage; and Pennsylvania, which almost tripled its ratio of civil engineer graduates to total engineers.

TABLE 7

RATIO OF ENGINEERING AIDS (TECHNICIANS) TO ENGINEERS IN STATE HIGHWAY DEPARTMENTS BY CENSUS REGION

Census Region	March 1956			January 1960		
	Engr.	Aids (Tech.)	Ratio	Engr.	Aids (Tech.)	Ratio
New England	1,942	1,631	0.84	2,210	1,788	0.81
Middle Atlantic	2,224	1,819	0.82	2,747	4,270	1.55
South Atlantic	2,587	5,023	1.94	3,470	7,468	2.15
East North Central	2,957	2,775	0.94	3,673	5,179	1.41
East South Central	1,429	2,209	1.55	1,620	5,259	3.25
West North Central	2,224	3,300	1.48	2,614	5,326	2.04
West South Central	1,495	4,634	3.10	1,814	6,398	3.53
Mountain	1,009	2,562	2.54	1,393	3,514	2.52
Pacific	—	—	—	3,967	5,014	1.26
Pacific[1]	4,684	1,958	0.42	3,842	4,775	1.24
Total	—	—	—	23,508	44,216	1.88
Total: 48 States and D. C.	20,551	25,911	1.26	23,383	43,977	1.88

[1] Does not include Alaska and Hawaii.

As was the case in 1956, all employees classified as engineers in New Mexico are registered; in 1960 Colorado only had 11.2 percent registered, although in 1956 Colorado had more than 40 percent of its engineers registered. North Carolina jumped from a registered figure of 8.3 percent in 1956 to over 72 percent in 1960.

Of the highway department employees classified as engineering aids (technicians), 173 have civil engineering degrees and one-fourth of this group are also registered civil engineers. In addition, 100 others have an engineering degree in another branch of engineering and 834 have a non-engineering college degree.

Of the 23,508 engineers employed by State highway departments, 334 or less than 1½ percent have advanced college degrees; nine of this number have doctor's degrees. As shown in Table 10, about one-sixth of the engineers with advanced degrees were hired during the year 1959; and it was expected that 41 more would be hired during 1960.

Illinois and Michigan employ the largest number of engineers with advanced degrees, 48 and 42, respectively. Several States employ but one or two. It will be interesting to watch these figures in years to come to see if the educational level in the highway field is comparable with other areas of engineering activity.

TABLE 8

STATE HIGHWAY DEPARTMENT ENGINEERING EMPLOYEES ASSIGNED TO MAINTENANCE

State	March 1956[1]			January 1960		
	Engr.	Aids (Tech.)	Total	Engr.	Aids (Tech.)	Total
Ala.	—	—	—	52	11	63
Alaska	—	—	—	—	—	(²)
Ariz.	—	—	—	—	569	569
Ark.	28	—	28	3	3	6
Calif.	(68)	—	(68)	60	30	90
Colo.	—	—	—	1	—	1
Conn.	—	—	—	26	6	32
Del.	(5)	(7)	(12)	5	37	42
Fla.	33	—	33	51	4	55
Ga.	27	5	32	18	2	20
Hawaii	—	—	—	—	—	(³)
Idaho	42	—	42	4	2	6
Illinois	85	1	86	85	32	117
Ind.	21	16	37	19	16	35
Iowa	36	—	36	35	1	36
Kan.	11	—	11	8	—	8
Ky.	30	—	30	46	—	46
La.	46	—	46	51	—	51
Me.	2	—	2	9	—	9
Md.	26	—	26	27	—	27
Mass.	53	37	90	67	26	93
Mich.	17	—	17	25	—	25
Minn.	20	—	20	19	—	19
Miss.	10	41	51	8	20	28
Mo.	36	—	36	37	—	37
Mont.	11	—	11	2	—	2
Neb.	—	—	—	11	1,123	1,134
Nev.	—	—	—	15	—	15
N.H.	12	—	12	46	15	61
N.J.	6	—	6	22	13	35
N.Mex.	11	10	21	14	14	28
N.Y.	(126)	(19)	(145)	125	38	163
N.C.	36	48	84	63	112	175
N.D.	6	—	6	7	—	7
Ohio	35	26	61	53	133	186
Okla.	11	—	11	8	(²)	8
Ore.	27	2	29	20	5	25
Pa.	28	—	28	27	142	169
R.I.	4	—	4	4	12	16
S.C.	54	—	54	26	—	26
S.D.	1	—	1	1	—	1
Tenn.	—	—	—	27	—	27
Tex.	17	300	317	23	—	23
Utah	7	6	13	2	—	2
Vt.	23	1	24	24	—	24
Va.	—	—	—	—	—	(³)
Wash.	9	—	9	12	—	12
W.Va.	15	90	105	34	132	166
Wis.	21	33	54	36	35	71
Wyo.	5	—	5	7	—	7
D.C.	2	—	2	2	20	22
Total	—	—	—	1,267	2,553	3,820
Total: 48 States and D.C.	1,063	642	1,705	1,267	2,553	3,820

[1] Figures in parenthesis are estimates for States that did not furnish data.
[2] States reported information was not available.
[3] Hawaii and Virginia do not separate maintenance employees from other employees.

TABLE 9

PERCENTAGES OF GRADUATE AND REGISTERED CIVIL ENGINEERS AMONG TOTAL CLASSIFIED ENGINEERS EMPLOYED

State	March 1956[1]					January 1960				
	Total Classified Engr	Graduate Civil Engineers		Registered Civil Engineers		Total Classified Engr.	Graduate Civil Engineers		Registered Civil Engineers	
		Number[2]	Percentage	Number[2]	Percentage		Number[2]	Percentage	Number[2]	Percentage
Ala.	(521)	(45)	(8.6)	(41)	(7 9)	472	129	27.3	383	81.1
Alaska	—	—	—	—	—	(11)	(4)	(36 4)	(4)	(36.4)
Ariz.	56	30	53.6	53	94.6	88	62	70.5	71	80.7
Ark.	137	52	38.0	78	56.9	141	79	56.0	82	58.2
Calif.	(3,562)	(1,427)	(40.1)	(784)	(22.0)	2,149	1,419	58 7	1,018	42.1
Colo.	329	38	11.6	140	42 6	330	28	8.5	37	11.2
Conn.	713	116	16.3	81	11.4	492	154	31 3	64	13 0
Del.	(43)	(28)	(65.1)	(20)	(46.5)	61	43	70.5	29	47.5
Fla.	352	114	32 4	92	26.1	534	121	22 7	111	20.8
Ga.	581	93	16.0	150	25 8	811	131	16.2	146	18.0
Hawaii	—	—	—	—	—	114	91	79 8	37	32.5
Idaho	139	68	48.9	69	49.6	115	96	61.9	83	53.5
Ill.	1,054	639	60 6	509	48.3	1,230	890	72.4	552[3]	44 9[3]
Ind.	360	350	97.2	270	75.0	456	412	90.4	288	63 2
Iowa	222	130	58.6	204	91.9	311	222	71.4	231	74.3
Kan.	310	152	49.0	243	78.4	472	292	61.9	225	47 7
Ky.	577	97	16.8	210	36 4	579	193	33.3	222	38.3
La.	305	80	26 2	305	100.0	398	175	44.0	375	94.2
Me.	170	96	56.5	93	54.7	222	137	61 7	103	46 4
Md.	390	43	11.0	43	11.0	483	32	6.6	51	13.8
Mass.	600	375[4]	62.5[4]	350[4]	58.3[4]	873	280	32.1	543	62.2
Mich.	499	263	52.7	138	27.7	806	541	67.1	245	30.4
Minn.	605	233	38.5	342	56.5	459	199	43 4	336	73.2
Miss.	106	66	62.3	81	76.4	214	169	79.0	118	55.1
Mo.	643	243	37.8	264	41 1	850	353	41.5	252	29.6
Mont.	204	29	14.2	80	39.2	275	39	14.2	107	38 9
Neb.	241	55	22 8	97	40 2	247	53	21.5	139	56.3
Nev.	(85)	(33)	(38 8)	(32)	(37 6)	174	15	8.6	41	23.6
N.H.	215	95	44.2	65	30 2	290	144	49.7	66	22.8
N.J.	425	(164)	(38.6)	(161)	(37.9)	528	142	26.9	93	17 6
N.Mex.	48	26	54.2	48	100.0	43	18	41.9	43	100.0
N.Y.	(1,273)	(362)	(28.4)	(334)	(26 2)	1,423	519	36.5	419	29.4
N.C.	448	141	31.5	37	8.3	553	189	34.2	40	72.3
N.D.	119	39	32 8	52	43 7	150	69	46.0	50	33.3
Ohio	651	390	59.9	597	91 7	694	475	68 4	560	80.7
Okla.	140	49	35.0	77	55 0	79	25	31.6	46	58 2
Ore	509	113	22 2	104	20.4	516	136	26 4	116	22.5
Pa.	526	55	10.5	75	14.3	796	220	27.6	130	16.3
R.I.	85	18	21.2	28	32.9	89	20	22.5	31	34 8
S C	264	115	43.6	25	9.5	205	107	52.2	36	17.6
S.D.	84	43	51.2	20	23 8	125	57	45 6	23	18.4
Tenn	(225)	(87)	(38.7)	(85)	(37.8)	355	87	24.5	72	20.3
Tex.	913	698	76.5	737	80 7	1,196	831	69 5	896	74.9
Utah	55	(22)	(40 0)	(21)	(38.2)	161	57	35.4	40	24 8
Vt.	159	64	40 3	44	27 7	244	114	46 7	61	25.0
Va.	347	72	20 7	87	25.1	570	131	23.0	83	14.6
Wash	613	180	29.4	107	17.5	907	212	23 4	170	18.7
W. Va.	81	32	39.5	81	100 0	146	68	46.6	92	63.0
Wis.	393	212	53.9	120	30.5	487	369	75.8	178	36.6
Wyo.	93	38	40.9	80	86 0	167	84	50 3	82	49.1
D.C.	81	32	39.5	10	12.3	107	67	62.6	18	16.8
Total	—	—	—	—	—	23,508	10,500	44 7	9,238	39.3
Total 48 States and D.C.	20,551	7,942	38.6	7,764	37 8	23,383	10,405	44 5	9,197	39.3

[1] Figures in parenthesis are estimates for States that did not furnish data. In most cases, estimates are based on data reported to Highway Research Board for July 1, 1956.
[2] Graduate and registered engineers are not additive on this table because some engineers are both graduate and registered.
[3] Illinois does not register civil engineers separately from other engineers
[4] Massachusetts indicated that information was estimated.

ENGINEERING PERSONNEL NEEDS

States that reported said they needed 1,298 more engineers and 1,866 more engineering aids (technicians) in January 1960 than were actually employed (Table 11). This represents a total need of 4.7 percent more engineering employees than were on the payroll. Twenty-three States did not report any need for additional engineering employees at the moment, although New York reported they needed 674. According to the States, in 1965 they will need about 9 percent more engineering personnel than were actually employed in January 1960. Of this total, engineers constitute about 40 percent of the needs.

It is difficult to determine just how accurate these estimates may be. Some States were reluctant to report any increase, whereas others may have somewhat overes-

TABLE 10

STATE HIGHWAY DEPARTMENT ENGINEERS HOLDING ADVANCED ENGINEERING DEGREES

State[1]	Permanent Full-Time Jan. 1960		Number Hired During 1959		Number to Be Hired During 1960	
	Masters	Doctors	Masters	Doctors	Masters	Doctors
Ala.	3	—	3	—	2	—
Alaska	1	—	1	—	([2])	([2])
Ariz.	1	—	—	—	—	—
Ark.	3	—	1	—	—	—
Calif.	35	—	—	—	—	—
Colo.	1	—	—	—	—	—
Conn.	3	—	—	—	—	—
Del.	6	—	—	—	—	—
Fla.	8	—	—	—	—	—
Ga.	4	—	1	—	—	—
Hawaii	2	—	—	—	—	—
Idaho	2	—	—	—	2	—
Ill.	46	2	18	—	2	—
Ind.	4	—	1	—	2	—
Iowa	3	1	—	—	1	—
Kan.	2	—	—	—	—	—
Ky.	6	—	—	—	2	—
La.	3	—	2	—	2	—
Me.	3	—	—	—	—	—
Md.	—	—	—	—	—	—
Mass.	5	—	—	—	—	—
Mich.	41	1	7	—	8	—
Minn.	11	—	2	—	2	—
Miss.	—	—	—	—	—	—
Mo.	10	—	—	—	—	—
Mont.	2	—	—	—	—	—
Neb.	4	—	1	—	—	—
Nev.	1	—	—	—	—	—
N.H.	—	—	—	—	—	—
N.J.	7	1	—	—	—	—
N.Mex.	1	—	—	—	—	—
N.Y.	19	—	4	—	3	—
N.C.	2	—	—	—	—	—
N.D.	—	1	—	—	—	—
Ohio	9	1	4	—	1	—
Okla.	—	—	—	—	—	—
Ore.	1	—	1	—	—	—
Pa.	21	2	2	—	7	—
R.I.	—	—	—	—	—	—
S.C.	—	—	—	—	—	—
S.D.	4	—	2	—	—	—
Tenn.	4	—	—	—	—	—
Tex.	—	—	—	—	—	—
Utah	5	—	—	—	1	1
Vt.	2	—	—	—	—	—
Va.	10	—	—	—	—	—
Wash.	14	—	4	—	4	—
W. Va.	5	—	—	—	—	—
Wis.	9	—	2	—	—	—
Wyo.	1	—	—	—	—	—
D.C.	1	—	1	—	1	—
Total	325	9	57	—	40	1
Total: 48 States and D.C.	322	9	56	—	40	1

[1] States reported only higher degree held.

[2] Alaska stated that estimates were not available as they were still being organized.

TABLE 11

STATE HIGHWAY DEPARTMENT ENGINEERING PERSONNEL NEEDS[1]

State	No. Needed Jan. 1960 Over Actual No. on Rolls Jan. 1960		No. Needed Jan. 1961 Over Actual No. on Rolls Jan. 1960		No. Needed Jan. 1962 Over Actual No. on Rolls Jan. 1960		No. Needed Jan. 1965 Over Actual No. on Rolls Jan. 1960	
	Engr.	Aids (Tech.)	Engr.	Aids (Tech.)	Engr.	Aids (Tech.)	Engr.	Aids (Tech.)
Ala.	20	—	20	—	10	—	10	—
Alaska[2]	—	—	—	—	—	—	—	—
Ariz.	—	—	10	20	10	20	15	30
Ark.	—	—	5	10	10	20	15	30
Calif.	10	20	—	—	—	—	—	—
Colo.	—	—	—	—	—	—	—	—
Conn.	26	50	30	160	5	20	—	—
Del.	10	—	15	5	20	10	25	15
Fla.	15	75	35	150	60	225	100	300
Ga.	—	—	—	—	—	—	—	—
Hawaii	32	79	52	117	78	160	106	214
Idaho	—	—	5	10	10	15	25	25
Ill.	130	151	147	164	152	165	157	167
Ind.	85	30	170	60	255	90	310	110
Iowa	—	—	5	10	5	10	5	10
Kan.	—	—	10	—	10	—	10	—
Ky.	50	100	50	100	50	100	50	100
La.	35	—	35	—	35	—	35	—
Me.	—	—	6	10	10	10	10	10
Md.	35	84	—	—	—	—	—	—
Mass.	26	38	52	75	52	75	70	90
Mich.	39	—	—	—	—	—	—	—
Minn.[3]	—	—	—	—	—	—	—	—
Miss.	33	121	17	41	23	67	30	85
Mo.[3]	69	100	30	70	—	—	—	—
Mont.	—	—	10	30	20	60	60	90
Neb.	10	10	20	20	30	40	50	80
Nev.	—	—	1	—	4	12	7	17
N.H.[4]	—	—	—	—	—	—	—	—
N.J.[5]	27	23	75	136	105	176	135	236
N.Mex.	4	192	4	192	4	192	4	192
N.Y.	319	355	385	426	458	590	518	781
N.C.	—	—	—	—	—	—	—	—
N.D.	—	—	5	50	8	75	20	100
Ohio	103	91	93	130	86	88	103	130
Okla.	—	—	31	31	31	31	31	31
Ore.	—	—	—	—	15	15	15	15
Pa.	96	154	117	207	170	305	193	390
R.I.	15	20	20	20	25	25	30	30
S.C.[4]	—	—	—	—	—	—	—	—
S.D.	—	—	—	—	—	—	—	—
Tenn.[3]	10	30	—	—	—	—	—	—
Tex.	—	—	—	—	—	—	—	—
Utah	25	40	25	40	20	30	20	30
Vt.	25	20	25	20	25	20	25	20
Va.	—	—	20	50	40	100	100	250
Wash.	—	—	—	—	—	—	50	100
W.Va.	12	40	—	—	—	—	—	—
Wis.	—	—	—	—	—	—	—	—
Wyo.	5	10	9	15	15	25	25	40
D.C.	32	33	77	78	87	78	92	78
Total	1,298	1,866	1,611	2,447	1,938	2,849	2,451	3,796
Total: 48 States and D.C.	1,266	1,787	1,559	2,330	1,860	2,689	2,345	3,582

[1] These estimates include permanent, full-time engineering personnel. They exclude summer help and other temporary employees.

[2] Alaska stated that estimates were not available as they were still being organized.

[3] States anticipate no increases unless Federal-Aid Program changes.

[4] New Hampshire reported "unknown"; whereas South Carolina said "not readily available, but believe not an appreciable amount."

[5] New Jersey actual needs are greater than those reported. They have reported only numbers of vacancies that they are permitted to fill.

timated their needs. Many States gave a qualified answer to this question. Common were such replies as "depends on Federal-aid program," or "need more, but personnel not available." In one case there was a disagreement as to present and future needs: the personnel director's estimate was considerably lower than that of one district engineer.

In addition the engineering personnel needs as reported in Table 11 do not, in some cases, compare favorably with the 1960 hiring plans, as given in Table 12. For example, California reported plans to hire 100 engineers during 1960. However, they stated that for January 1961 they would not require any additional engineers over the actual number on the rolls during January 1960. It may be that additional engineers are needed as replacements or that discrepancies such as these are the fault of the questionnaire rather than any inaccuracy in reporting.

ENGINEERS PER MILLION DOLLARS OF CAPITAL OUTLAY

One of the most significant findings of the study is that the engineering manpower used by State highway departments for each million dollars of capital outlay has decreased by a wide margin from 1956 to 1960 (Tables 13 and 14).

Based on 1955 capital outlay figures and March 1956 engineering employees, and 1959 capital outlays and January 1960 employees, engineering employees per million dollars of capital outlay have decreased from 19.6 in 1955 to 13.0 in 1959. Considering engineers alone, the improvement is even more remarkable—from 8.5 to 4.5; in other words, from a dollar viewpoint the output per engineer has nearly doubled.

It should be pointed out that the capital outlay figures used omit toll facilities except for those States where toll roads are directly under the jurisdiction of the State highway department. All outlay for toll bridge facilities has been omitted. To the extent that State highway engineering personnel aid in the planning and construction of these structures, these figures are in error. No attempt has been made to take into consideration any differences among the States regarding the proportion of money spent for right-of-way, but it may be considerable between 1955 and 1959.

Using data from the earlier study, the range in engineers per million dollars of capital outlay was from 1.6 in New Mexico to 23.1 in Vermont; whereas the number of aids varied from 1.6 in Illinois to 37.4 in Idaho; for engineers and aids combined, the variation was from 7.7 in West Virginia to 53.7 in Alabama.

In the 1960 study, the number of engineers per million dollars of capital outlay varied from 0.6 in New Mexico to 12.6 in Washington; whereas the number of aids varied from 2.1 in Idaho to 18.8 in Tennessee; for engineers and aids combined, the variation was from 7.1 in Indiana to 24.6 in Alabama. The average for all States and the District of Columbia was 4.5 engineers and 8.5 aids, or a total of 13.0 engineering employees per million dollars of capital outlay, which average represents approximately a 31 percent decrease in the number of engineering personnel per million dollars of capital outlay as compared with the 1956 study.

There is no obvious explanation for the wide variations which exist among the several States. It might be noted, however, that these variations are much more extreme for engineers or aids alone than for engineers and aids combined. Obviously, then, the combination of engineers and aids is a better comparative measure of engineering effort. This is the same conclusion reached by Lewis in his six-state classification study in 1955 (2).

There appears to be little relation between the size of the program and the number of engineers and aids employed per million dollars of capital outlay. Alabama and West Virginia, with comparable capital outlays, are at opposite extremes with respect to engineering personnel employed per million dollars of capital outlay; Alabama had one of the highest figures, whereas West Virginia had one of the lowest. Arizona and New Mexico, also with comparable capital outlays, were very low as to the number of engineers employed; but among the highest with respect to aids.

The purpose of tabulating information on the number of engineering employees per million dollars of capital outlay was to indicate the amount of variation among the several States in this respect, and possibly to find some unit for measuring relative efficiency.

TABLE 12

NUMBER OF ENGINEERS EMPLOYED DIRECTLY FROM COLLEGE WITH A BACHELOR OF SCIENCE IN ENGINEERING

State	Hired During 1959			Plan to Hire During 1960		
	Civil	Non-Civil	Total	Civil	Non-Civil	Total
Ala.	20	—	20	15	5	20
Alaska	—	—	—	—	—	—
Ariz.	8	1	9	5	—	5
Ark.	12	—	12	6	1	7
Calif.	283	—	283	100	—	100
Colo.	3	1	4	—	—	—
Conn.	9	—	9	26	—	26
Del.	5	1	6	10	—	10
Fla.	18	—	18	20	—	20
Ga.	10	—	10	([1])	—	([1])
Hawaii	31	1	32	25	3	28
Idaho	12	—	12	12	—	12
Ill.	115	12	127	106	—	106
Ind.	80	—	80	80[2]	5[2]	85[2]
Iowa	18	—	18	20	—	20
Kan.	26	2	28	10	—	10
Ky.	62	—	62	50	—	50
La.	30	5	35	35	—	35
Me.	3	—	3	10	—	10
Md.	—	—	—	3	—	3
Mass.	—	—	—	—	—	—
Mich.	30	2	32	45	—	45
Minn.	42	—	42	20	1	21
Miss.	40	—	40	18	—	18
Mo.	39	—	39	30	—	30
Mont.	6	2	8	10	5	15
Neb.	3	5	8	4	5	9
Nev.	1	—	1	2	—	2
N.H.	10	—	10	5	—	5
N.J.	23	5	28	25	—	25
N.Mex.	3	—	3	4	2	6
N.Y.	77	13	90	66	11	77
N.C.	14	—	14	10	—	10
N.D.	13	3	16	5	—	5
Ohio	26	—	26	86	16	102
Okla.	—	—	—	—	—	([3])
Ore.	24	3	27	15	—	15
Pa.	50	—	50	65	13	78
R.I.	3	—	3	—	—	([3])
S.C.	7	—	7	—	—	([1])
S.D.	7	—	7	25	—	25
Tenn.	14	—	14	10	—	10
Tex.	106	12	118	80	—	80
Utah	8	—	8	10[3]	([3])	10[3]
Vt.	11	—	11	15	—	15
Va.	22	—	22	20	—	20
Wash.	33	—	33	8	—	8
W.Va.	16	1	17	10	—	10
Wis.	58	1	59	20	—	20
Wyo.	13	—	13	10	—	10
D.C.	12	—	12	18	1	19
Total	1,456	70	1,526	1,169	68	1,237
Total: 48 States and D.C.	1,425	69	1,494	1,144	65	1,209

[1] Georgia and South Carolina indicated inability to forecast this information.
[2] Indiana stated they "may" be able to hire this number of engineers.
[3] States indicated that their plans depend on the availability of engineers.

TABLE 13

STATE HIGHWAY DEPARTMENT ENGINEERING EMPLOYEES PER MILLION DOLLARS OF CAPITAL OUTLAY (EXCLUDING MAINTENANCE EMPLOYEES)

State	1955 Capital Outlay ($mil)[1]	March 1956 Engr.	March 1956 Aids (Tech.)	March 1956 Total	1959 Capital Outlay ($mil)[1]	January 1960 Engr.	January 1960 Aids (Tech.)	January 1960 Total
Ala.	24.3	21.4	32.3	53.7	65.6	6.4	18.2	24.6
Alaska	—	—	—	—	14.3	0.8	0.9	1.7
Ariz.	16.7	3.3	30.2	33.5	38.7	2.3	18.1	20.4
Ark.	21.7	5.0	17.8	22.8	38.7	3.6	12.2	15.8
Calif.	252.9	13.8	5.2	19.0	379.4	6.2	10.1	16.3
Colo.	25.9	12.7	16.9	29.6	55.1	6.0	7.5	13.5
Conn.	46.4[2]	15.4	5.1	20.5	81.4[2]	5.7	7.2	12.9
Del.	8.7	4.4	15.7	20.1	21.7	2.6	10.9	13.5
Fla.	74.6[2]	4.3	15.8	20.1	158.8[2]	3.1	9.9	13.0
Ga.	49.3	11.2	25.0	36.2	78.3	10.1	11.1	21.2
Hawaii	—	—	—	—	15.4	7.4[3]	14.7[3]	22.1[3]
Idaho	12.1	8.0	37.4	45.4	28.4	5.3	2.1	7.4
Ill.	93.0	10.4	1.6	12.0	227.6	5.0	3.9	8.9
Ind.	39.4	8.6	3.9	12.5	106.0	4.1	3.0	7.1
Iowa	40.9	4.5	18.2	22.7	92.7	3.0	7.6	10.6
Kan.	30.0	10.0	18.7	28.7	73.4	6.3	7.0	13.3
Ky.	67.7[2]	8.1	8.6	16.7	130.4[2]	4.1	11.0	15.1
La.	54.5	4.7	17.0	21.7	148.0	2.3	9.3	11.6
Me.	19.6	8.6	2.9	11.5	34.8	6.1	3.0	9.1
Md.	61.1	6.0	6.1	12.1	74.6	6.1	8.4	14.5
Mass.	82.0	6.7	12.5	19.2	124.2	6.5	5.8	12.3
Mich.	82.4	5.9	9.7	15.6	186.7	4.2	5.2	9.4
Minn.	53.1	11.0	12.0	23.0	106.2	4.1	10.2	14.3
Miss.	27.2	3.5	20.2	23.7	55.3	3.7	15.5	19.2
Mo.	70.8	8.6	10.2	18.8	118.2	6.9	7.6	14.5
Mont.	17.4	11.1	16.3	27.4	40.8	6.7	7.4	14.1
Neb.	25.1	9.6	9.0	18.6	40.4	5.8	9.9	15.7
Nev.	9.6	8.9	10.4	19.3	18.8	8.4	8.6	17.0
N. H.	16.2[2]	12.5	7.4	19.9	27.1[2]	9.0	2.2	11.2
N. J.	28.8	14.5	2.7	17.2	71.5	7.1	4.7	11.8
N. Mex.	23.0	1.6	22.2	23.8	49.6	0.6	12.1	12.7
N. Y.	119.0	9.6	5.6	15.2	373.7	3.5	3.9	7.4
N. C.	68.3	6.0	8.2	14.2	87.8	5.6	7.7	13.3
N. D.	14.8	7.6	3.1	10.7	40.4	3.5	5.1	8.6
Ohio	110.9	5.6	11.5	17.1	309.1	2.1	7.6	9.7
Okla.	34.0	3.8	16.7	20.5	71.8	1.0	7.5	8.5
Ore.	33.8	14.3	8.1	22.4	68.5	7.2	6.6	13.8
Pa.	111.5	4.5	9.4	13.9	267.9	2.9	8.5	11.4
R. I.	9.9	8.2	11.0	19.2	15.6	5.4	10.9	16.3
S. C.	22.9	9.2	19.4	28.6	70.0	2.6	13.6	16.2
S. D.	18.1	4.6	20.0	24.6	36.4	3.4	11.0	14.4
Tenn.	29.4	7.7	8.5	16.2	92.2	3.6	18.8	22.4
Tex.	139.8	6.4	17.6	24.0	336.1	3.5	11.9	15.4
Utah	13.2	3.6	7.1	10.7	42.2	3.8	9.8	13.6
Vt.	5.9	23.1	7.6	30.7	22.4	9.8	4.0	13.8
Va.	42.7	8.1	17.9	26.0	85.0	6.7[3]	15.6[3]	22.3[3]
Wash.	42.4	14.2	8.7	22.9	71.3	12.6	6.3	18.9
W. Va.	21.7	3.0	4.7	7.7	65.2	1.7	7.5	9.2
Wis.	47.3	7.8	6.7	14.5	86.0	5.2	5.1	10.3
Wyo.	13.5	6.5	12.2	18.7	35.9	4.4	7.7	12.1
D. C.	9.5	8.3	8.1	16.4	22.7	4.6	18.2	22.8
Total	—	—	—	—	4,902.3[2]	4.5	8.5	13.0
Total: 48 States and D. C.	2,283.0[2]	8.5	11.1	19.6	4,872.6[2]	4.5	8.5	13.0

[1] Figures rounded.
[2] Includes capital outlay for turnpike facilities in Connecticut, Kentucky, and New Hampshire, as well as 36th St. Expressway in Florida.
[3] Hawaii and Virginia do not separate maintenance from other employees.

In view of the wide variations which exist among the States, and the lack of any obvious explanation therefor, it appears impossible to relate such information with relative efficiency at this time. This information should be of interest to the States for purposes of self-appraisal, however, and could serve as a basis for more detailed studies.

TURNOVER OF ENGINEERING PERSONNEL

Table 15 shows that during the calendar year 1959, State highway departments hired 2,213 engineers and 8,646 engineering aids (technicians). This total of 10,859 new employees was accompanied by a loss of 1,577 engineers and 8,383 aids giving a net gain of 636 engineers and 263 aids (technicians).

What this large turnover of engineering personnel represents in terms of inefficiency is unknown, but it must be considerable. In some States, the amount of turnover, including deaths and retirements, is extremely high. Illinois, for example, hired 222 engineers during the year. However, this was accompanied by a loss of 119 through

TABLE 14

STATE HIGHWAY DEPARTMENT ENGINEERING EMPLOYEES PER MILLION DOLLARS OF CAPITAL OUTLAY BY CENSUS REGION

Census Region	March 1956: 1955 Capital Outlay ($ mil)	March 1956: Excluding Maintenance: Engr.	March 1956: Excluding Maintenance: Aids (Tech.)	March 1956: Excluding Maintenance: Total	January 1960: 1959 Capital Outlay ($ mil)	January 1960: Excluding Maintenance: Engr.	January 1960: Excluding Maintenance: Aids (Tech.)	January 1960: Excluding Maintenance: Total
New England	180.0	10.3	8.8	19.1	305.5	6.7	5.6	12.3
Middle Atlantic	259.3	8.0	6.9	14.9	713.1	3.6	5.7	9.3
South Atlantic	358.8	6.6	13.6	20.2	664.1	4.9	10.8	15.7
East North Central	373.0	7.4	7.2	14.6	915.4	3.8	5.4	9.2
East South Central	148.6	9.3	14.6	23.9	343.5	4.3	15.2	19.5
West North Central	252.8	8.4	13.0	21.4	507.7	4.9	8.3	13.2
West South Central	250.0	5.6	17.3	22.9	594.6	2.9	10.8	13.7
Mountain	131.4	7.1	19.4	26.5	309.5	4.3	9.5	13.8
Pacific	—	—	—	—	548.9	7.0	9.1	16.1
Pacific[1]	329.1	13.9	5.9	19.8	519.2	7.2	9.1	16.3
Total	—	—	—	—	4,902.3	4.5	8.5	13.0
Total: 48 States and D.C.	2,283.0	8.5	11.1	19.6	4,872.6	4.5	8.5	13.0

[1] Does not include Alaska and Hawaii.

death, retirement, or resignation. The State of Washington hired 44 new engineers but lost 101—in fact, including both engineers and aids, they had a net loss of 133 engineering personnel. Washington indicated, however, that this loss was due to curtailment of the Federal-aid highway program. Colorado also reported a substantial net loss of engineering personnel during 1959, due in part to curtailment of Federal aid. However, they also stated that part of the reduction in the payroll was due to introduction of the computer, aerial survey methods, and short-cuts in other engineering areas.

Nevertheless, it seems apparent that in the interest of economy and efficiency, many States must devote greater efforts toward retaining those qualified engineers and aids who are lost for reasons other than retirement.

CONCLUSION

The reason for undertaking this 1960 Inventory of State Highway Employment was primarily to develop trends in the employment of highway engineering manpower so that they in turn can be used as a tool in the study of effective manpower utilization. It also

TABLE 15

TURNOVER OF ENGINEERING PERSONNEL DURING CALENDAR YEAR 1959

State	Gains (Hirings)		Losses (Separations)		Net Gain or Loss		Total Net Gain or Loss
	Engr.	Aids (Tech.)	Engr.	Aids (Tech.)	Engr.	Aids (Tech.)	Engr Aids (Tech.)
Ala.	25	40	6	19	19	21	40
Alaska	3	6	—	—	3	6	9
Ariz.	12	283	6	253	6	30	36
Ark.	13	23	6	9	7	14	21
Calif.	180	337	132	550	48	-213	-165
Colo.[1]	7	35	9	109	-2	-74	-76
Conn	62	164	31	154	31	10	41
Del	10	28	6	21	4	7	11
Fla	18	433	34	374	-16	59	43
Ga	17	88	27	100	-10	-12	-22
Hawaii	47	51	23	26	24	25	49
Idaho	13	7	11	11	2	-4	-2
Ill	222	236	119	218	103	18	121
Ind	96	38	34	71	62	-33	29
Iowa	21	179	20	152	1	27	28
Kan.	28	189	3	41	25	148	173
Ky.	53	403	37	401	16	2	18
La.	73	369	51	319	22	50	72
Me.	11	99	14	102	-3	-3	-6
Md	2	106	12	64	-10	42	32
Mass.	—	40	5	40	-5	—	-5
Mich	71	195	50	75	21	120	141
Minn.	44	93	32	90	12	3	15
Miss	40	264	10	219	30	45	75
Mo	66	183	69	224	-3	-41	-44
Mont	30	41	16	15	14	26	40
Neb.	21	334	26	337	-5	-3	-8
Nev	16	14	12	35	4	-21	-17
N.H.	41	15	39	17	2	-2	—
N.J.	44	71	33	44	11	27	38
N. Mex	5	289	6	500	-1	-211	-212
N.Y.	119	382	90	259	29	123	152
N C.	45	76	36	122	9	-46	-37
N D	19	525	4	600	15	-75	-60
Ohio	87	560	68	706	19	-146	-127
Okla.	10	43	10	129	—	-86	-86
Ore	29	184	36	181	-7	3	-4
Pa.[2]	75	500	48	359	27	141	168
R.I.	11	43	6	34	5	9	14
S.C[3]	—	—	—	—	—	—	—
S.D	20	365	25	355	-5	10	5
Tenn.	31	347	15	281	16	66	82
Tex	192	145	121	—	71	145	216
Utah	32	401	12	261	20	140	160
Vt	16	5	20	17	-4	-12	-16
Va.	26	134	29	179	-3	-45	-48
Wash.[1]	44	54	101	130	-57	-76	-133
W. Va.	32	55	9	32	23	23	46
Wis	83	71	42	37	41	34	75
Wyo[4]	13	—	4	—	9	—	9
D.C.	38	103	22	111	16	-8	8
Total	2,213	8,646	1,577	8,383	636	263	899
Total 48 States and D.C.	2,163	8,589	1,554	8,357	609	232	841

[1] Colorado and Washington reported loss was due to a curtailment in Federal Highway Program.

[2] Pennsylvania stated that personnel separated and then rehired during 1959 were not included.

[3] South Carolina reported "not readily available but believe not an appreciable amount."

[4] Wyoming reported information for engineering aids (technicians) was "not available."

served as a check on the accuracy of the data secured in the 1956 Highway Research Board Inventory. In general it is now believed that, although there have been some puzzling data reported, the information is about as accurate as can be obtained in view of the different classification plans in use by the various State highway departments.

It has been pointed out that engineering personnel are not increasing nearly as rapidly as capital outlay, and that the ratio of aids to engineers is increasing. Coupled with the ever-increasing engineering standards, both of these findings indicate a more favorable use of engineering personnel.

In addition, it has been found that the percentage of graduate and registered engineers to total engineers employed has increased over the past four years. Thus, it is apparent that the professional level of highway engineers is on the rise.

Also discovered was the fact that nationwide highway engineering personnel needs, as expressed by the States, are not nearly as great as indicated by current popular opinion.

The analysis of the ratio of aids to engineers or the analysis of engineers per million dollars of capital outlay were not the primary purpose of this study, nor do they by themselves indicate effective manpower utilization. They serve to highlight, however, the type of guide which might be developed by the States to set some criteria for present and future manpower requirements.

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