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.

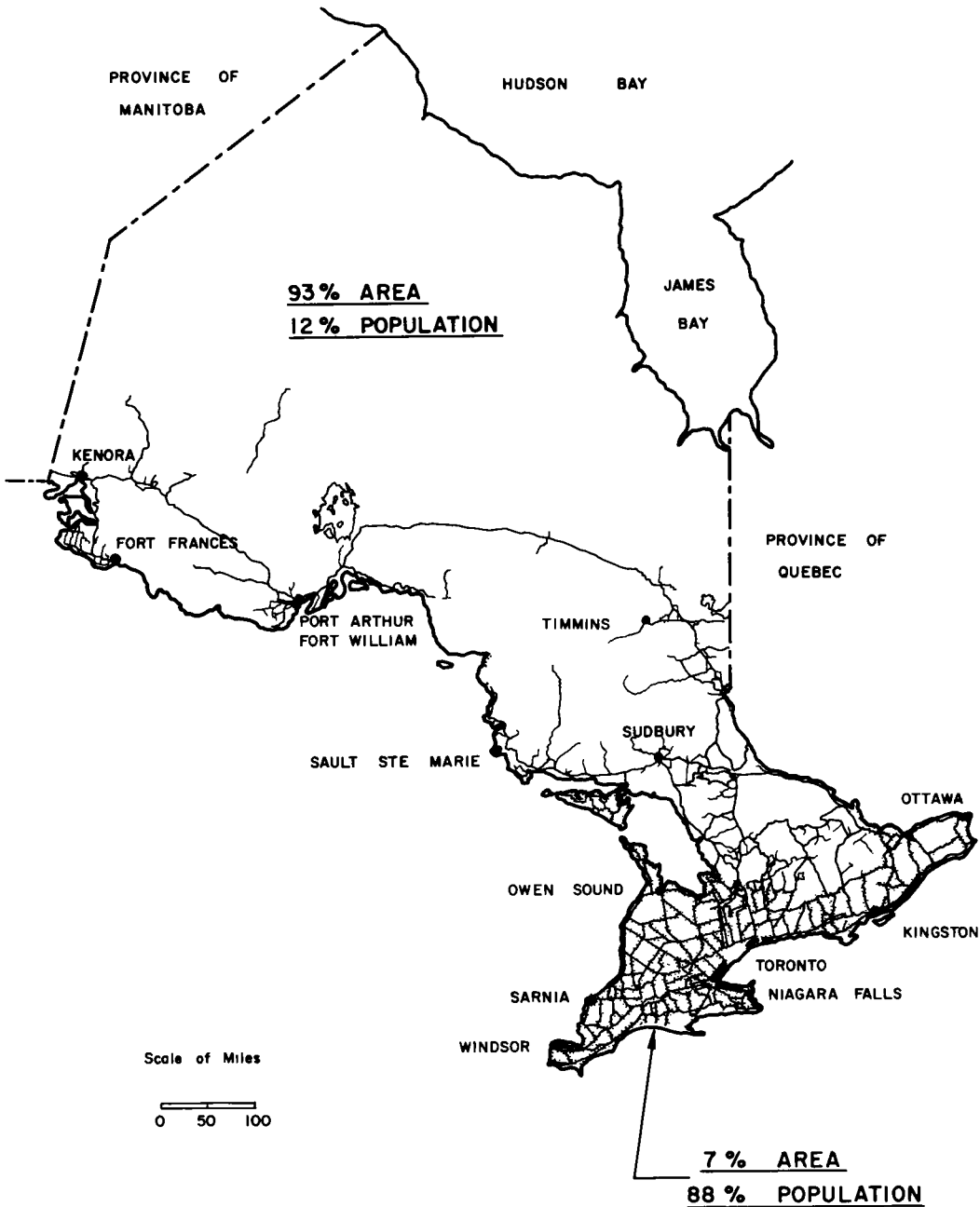

Figure 1. Province—controlled highways and population distribution.

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.

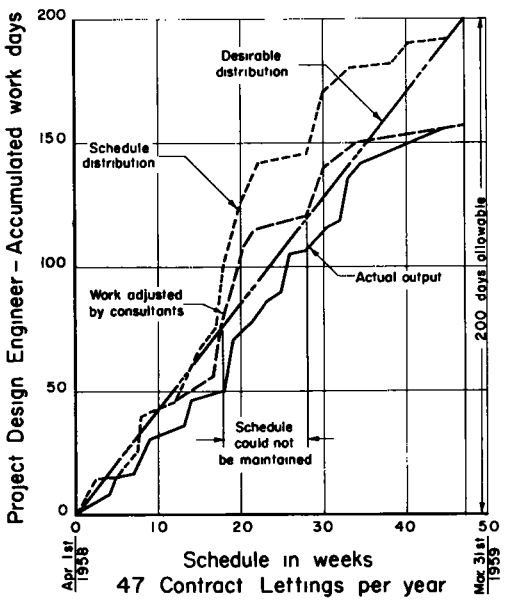

Figure 3. Work-time graph, 1958-1959 program, project design engineer "A".

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:

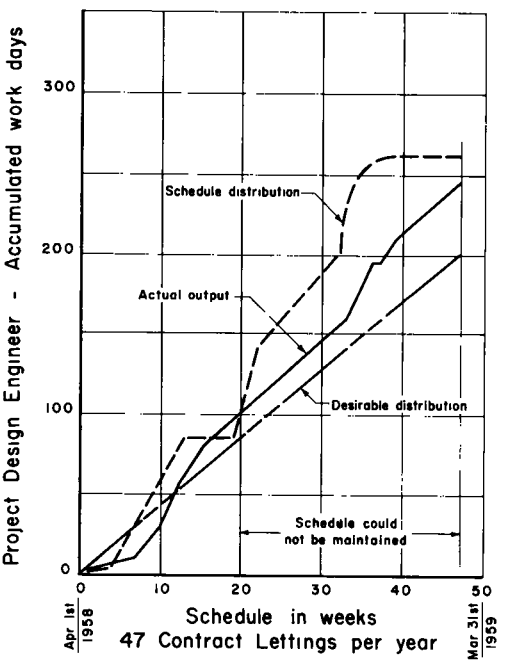

Figure 4. Work-time graph, 1958-1959 program, project design engineer "B".

	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 office 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;

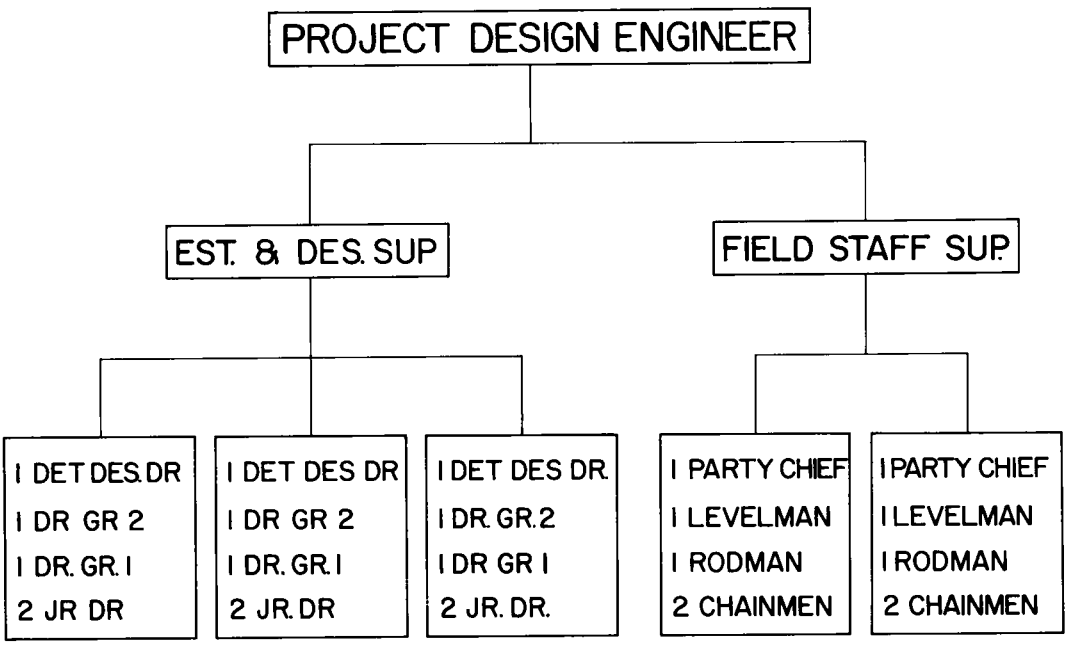

Figure 5.

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-dentralized 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-

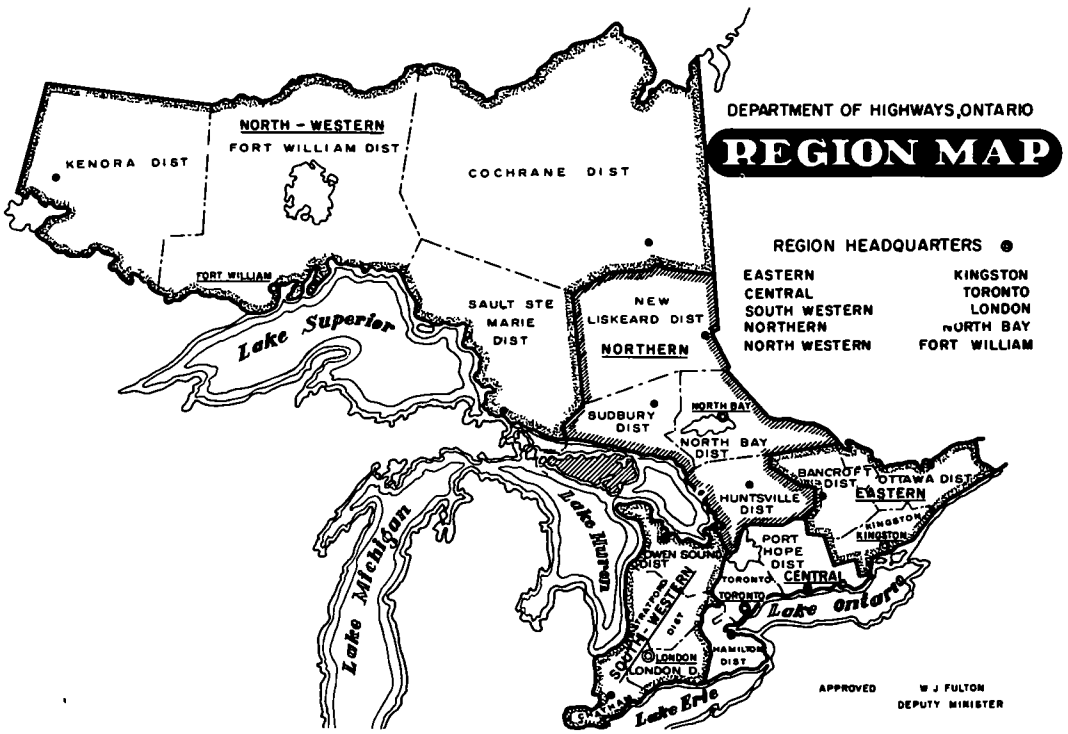

Figure 6.

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.

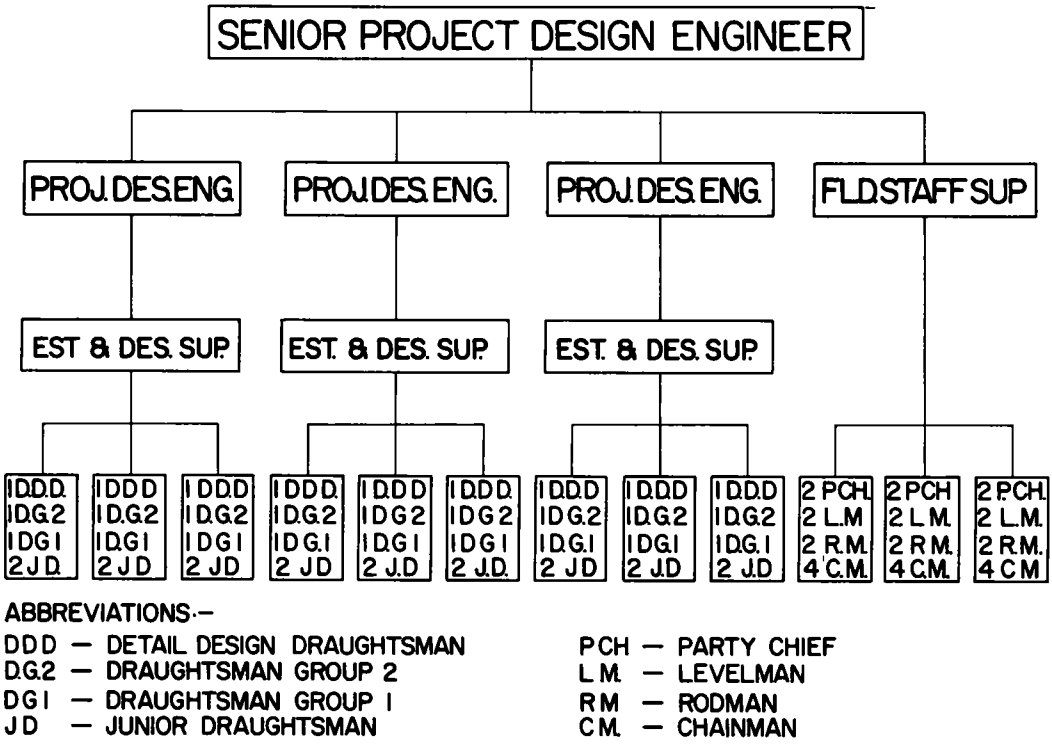

Figure 7.

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.

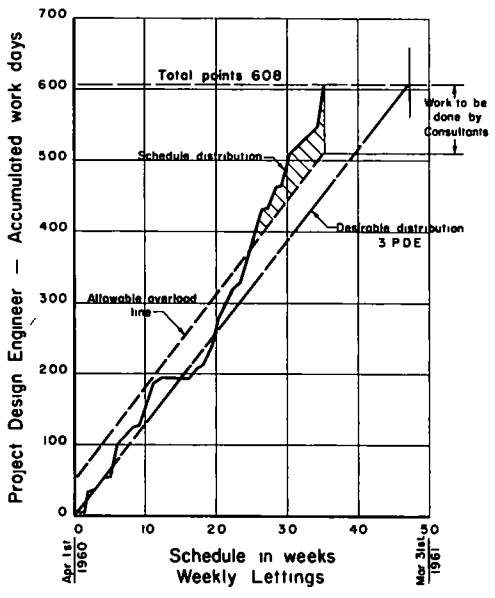

Figure 8. Work-time graph, 1960-1961 program, central region. Districts: Hamilton, Toronto and Port Hope.

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

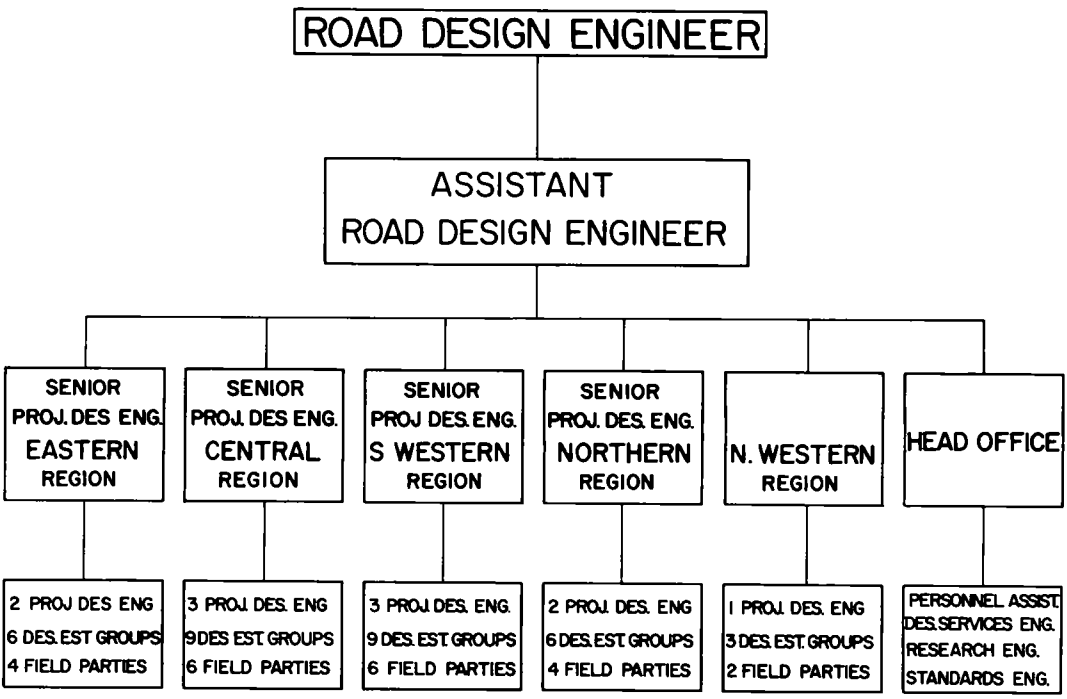

Figure 9.

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 evaluation 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

	Project Design Engineers			Estimators	
Type of Work	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			Estimators
	Basic Wk. Days	Work Days		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	Rural	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

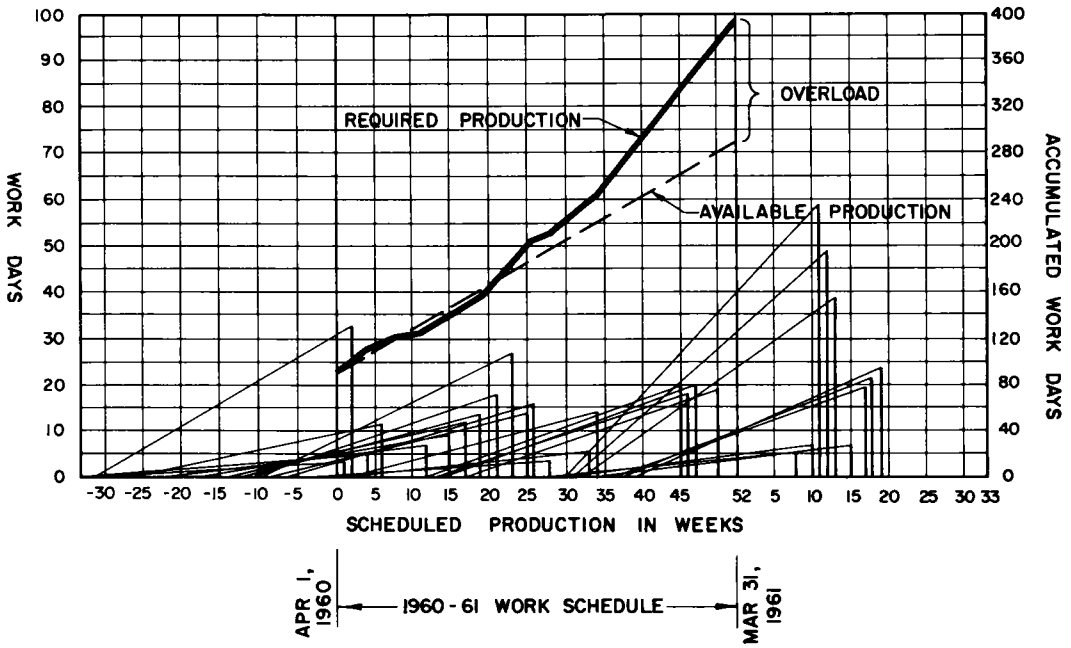

Figure 10. Work-time graph, 1960-1961 program, central region, one project design engineer, Toronto District.

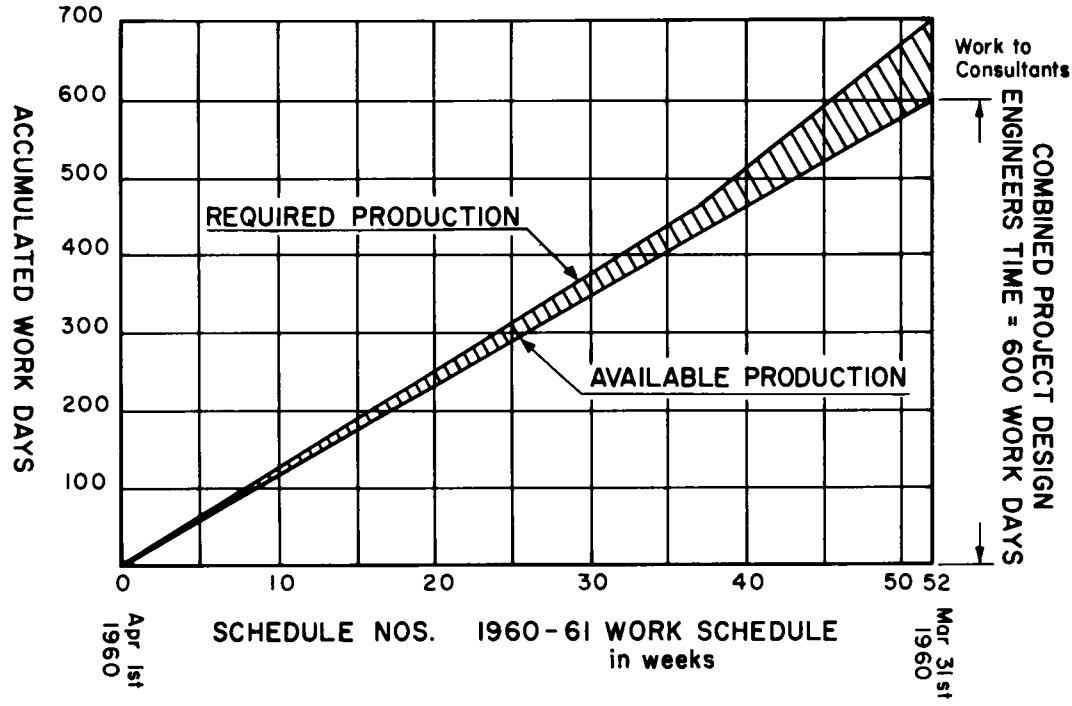

Figure 11. Combined work-time graph, project design engineers, central region.

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.