Determining Manpower Needs for Construction Inspection

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A manpower management objective was adopted by the North Dakota Department of Highways to (a) relate manpower to work loads in the construction inspection and materials testing functions, (b) express those relationships in terms of standard staffing patterns for standard work activities, (c) develop ways of reducing the standard staffing complements insofar as possible in order to increase the salary levels of the persons employed, (d) predict future manpower needs, and (e) develop manpower plans, programs, and policies based on future needs. A research project was undertaken to accomplish the manpower management objective. The study approaches used and the results obtained are discussed in this paper.

•THE North Dakota State Highway Department recognized a need to improve its methods of construction manpower planning and undertook a study to meet this requirement. This report describes that study.

In the spring of 1967, the Department initiated the study. The objectives of the study were (a) to develop realistic ways in which the construction work load could be anticipated in terms meaningful to manpower planners, and (b) to determine the personnel needed to meet the work load. The questions to be answered by the study included the following: (a) How many men are needed? (b) Where are they needed? (c) When will they be needed? (d) What special skills are needed? and (e) Is there adequate lead time for training?

This study was one part of a personnel management study that included the development of a new classification and salary structure, implementation of improved personnel policies and procedures, and determination of the training needs of the construction and materials work forces. These phases of the study influenced the results reported herein; however, a discussion of the entire program is beyond the scope of this report.

STATEMENT OF THE PROBLEM

The first efforts of the study were directed toward the identification of four major problems: (a) nature and level of seasonal employment, (b) adequacy of programming, (c) adaptability of the organization, and (d) current manpower planning methods.

Seasonal Employment

The Department has relied on a relatively small and stable permanent construction inspection work force while employing a relatively large number of seasonal (temporary) personnel to meet its construction requirements. The primary source of its seasonal personnel has been students who were seeking summer employment.

Figure 1 shows the level of staffing by month since 1962. This number of employees used has varied considerably from month to month, and from year to year. These

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variations are greatly intensified when the work loads of the individual districts are analyzed.

The temporary work force is largely untrained. The same persons do not tend to return year after year. In 1966, 70 percent of the seasonal work force had total Department experience of three months or less. Only five percent of these persons had Department experience amounting to one year or more.

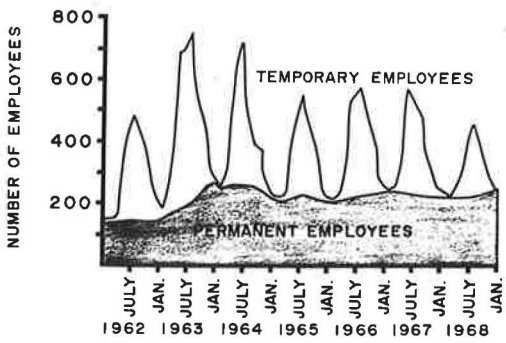

Figure 1. Monthly construction staffing.

At the peak of the 1967 construction period there was more than one seasonal employee for each permanent employee. This had been a relatively consistent ratio since 1965. Seasonal employees can be trained to perform only a few limited and routine assignments. They must be brought to a point where they can be productive rapidly. The amount of work they perform may be limited by the knowledge and skills they possess.

Programming

Construction programs are developed for a number of years in advance. The period being programmed now includes the year 2000. The program classifies the work to be undertaken into improvement types (types of projects). The program is based on highway needs and estimates of fund availability. The availability of construction inspection personnel is not a factor. Contract starting dates are scheduled for the coming three-year period. Expected completion dates are not scheduled.

Organization

The State of North Dakota is divided into seven districts. The districts are not officially divided into construction residencies. The flow of authority and responsibility is from the assistant district engineer directly to the project engineer, with functional control from headquarters.

Essentially two types of permanent construction inspection personnel are employed: (a) those permanently assigned to a district, and (b) a reserve "pool" of field personnel assigned to headquarters.

The headquarters "pool" is normally assigned to the various districts as needed for the duration of the construction period. These employees are usually returned to headquarters during the winter months. This procedure provides great flexibility in meeting shifting work loads, but demands the development of ways in which the work under way can be evaluated in terms of manpower requirements.

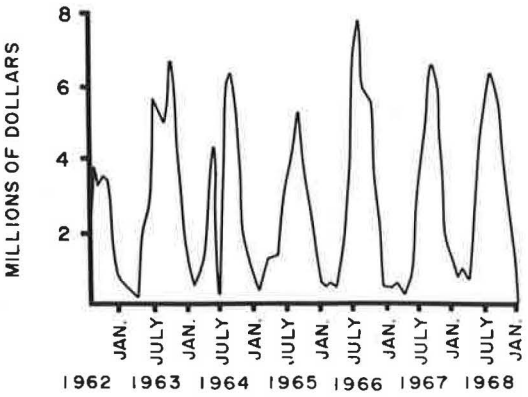

Figure 2. Monthly construction expenditures.

Manpower Planning Methods

The study staff reviewed current manpower planning methods. The primary method in use was the drawing of relationships between expenditures and manpower requirements.

Figure 2 shows the monthly construction expenditures since 1962. They vary widely and the level of each month's expenditure is difficult, if not impossible, to estimate.

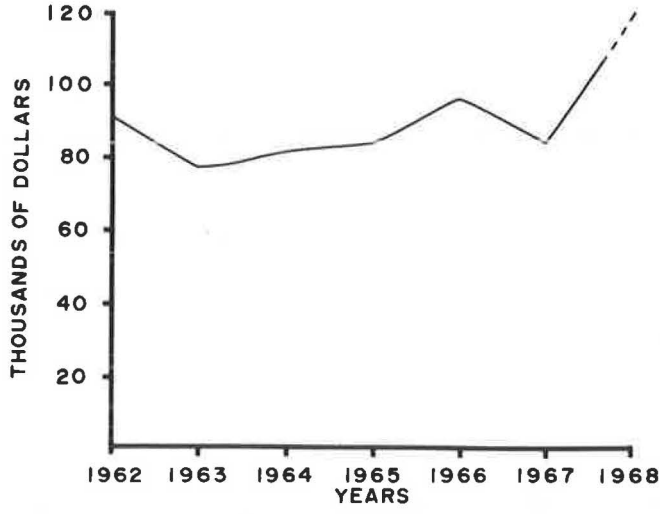

Figure 3. Annual dollars expended per man 1962 through 1968.

Figure 3 shows the relationships between expenditures and employment on an annual statewide basis since 1962. It varies more than 20 percent from the lowest level to the highest level. This variation is intensified as the management unit (districts and projects) becomes smaller and the time period analyzed becomes shorter. The variations are so large as to indicate that this is not a reliable method on which manpower needs may be based.

A similar analysis was done on miles constructed. The statewide results are shown in Figure 4. Again the variations are so large as to indicate that this guideline is ineffective as a manpower planning tool.

These relationships (manpower-expenditures-miles constructed) may be somewhat valid indicators of the overall effectiveness of manpower utilization, but they lack precision for manpower planning.

Figure 4. Miles constructed per man 1962 through 1968.

STUDY METHODS

The methods used in developing the construction manpower planning procedure involved three phases: (a) work identification, (b) work observations, and (c) historical analyses.

Work Identification

A Construction Manpower Committee composed of knowledgeable field personnel was formed. This Committee identified the principal elements involved in the construction inspection of roads and bridges and the significant tasks involved in each of these elements. The elements, which are called job elements, ranged from pre-construction inspection to

inspection management and included such items as road and bridge surveying, clearing and grubbing inspection, and excavation and embankment inspection. Twenty-seven job elements were defined in this manner.

Work Observations

A team of work observers was formed. This team was made up of four full-time men, with two other men filling in on a part-time basis.

Twenty-four different projects were selected throughout the state. These projects represented the major types of construction normally encountered in North Dakota and the various types of terrain that typify the area. One field trip was made into an adjoining state.

The work observers were furnished schedules that varied their time of arrival on the projects, and the routes of the observers were interchanged and varied. The objective was to provide as nearly a random observation pattern as travel distance and time would permit. The primary purpose of these observations were as follows:

1. A documentation of the number of men working on each project during the time of the observation and their physical location on the job.
2. The work being performed by each man at the time of the observation.
3. The type of construction under way, and the type and location of equipment being used by the contractor.

Historical Analyses

Construction records were compiled and analyzed. The primary purposes of these analyses were as follows:

1. Identification of the normal length of construction time (in calendar days) for the various types of projects.
2. An analysis of the numbers of personnel assigned to the various types of projects and the resultant effect of staffing variations on project costs.

In each instance, variables including unusual weather conditions, differences in terrain, inclusion or exclusion of structures, and variations in the contractor's procedures were isolated insofar as possible.

RESULTS

The results of the work observations were one of the principal findings of the study. These results were substantiated by the historical analyses.

Work Observations

The work observations substantiated that similar tasks and job elements are required for similar improvement types. However, in many instances one individual could perform several tasks included in two or more job elements over a short period of time. For example, one inspector could be involved in utilities relocation inspection, clearing and grubbing inspection, and excavation and embankment inspection on the same day. In fact, the more knowledgeable the inspector, the more likely he is to be involved in diverse activities.

Staffing variations were identified for similar projects. Figure 5 is an example of the variation between two projects that were very similar in every respect except staffing.

Subcontracting did not, in itself, change staffing requirements. The sequence of construction could alter the staffing requirements but not as greatly as previously anticipated. Primary impact was observed where essentially two projects were created. The doubling of contract forces, whether by subcontracting or by the addition of more personnel and equipment, did not double the requirement for inspection personnel.

Staffing variations were observed where two or more projects were close together. In this instance, the work on both could sometimes be staffed as though it were one project.

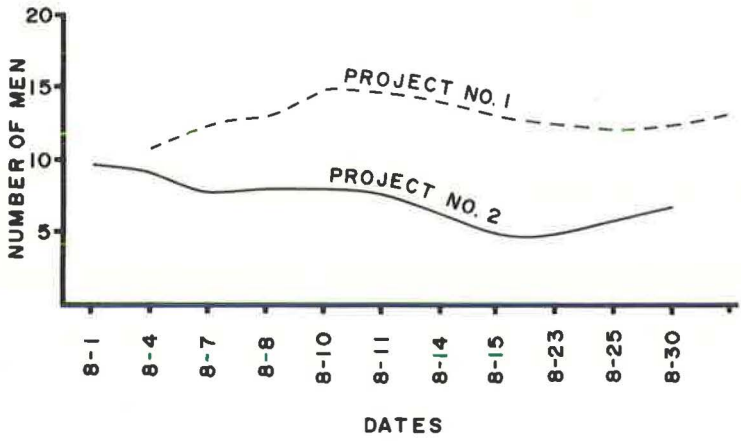

Figure 5. Variation in staffing construction projects.

Staffing variations did occur where more than one project was under the direct supervision of one man. The supervisor was then able to shift personnel from one job to the other to meet peak demand periods. This occurred only on projects where persons with the required knowledge and skills were available for shifting.

The number of persons assigned to particular jobs did tend to vary with the ratio of seasonal to permanent personnel, although this varied from project to project and supervisor to supervisor. In general, the more temporary personnel assigned to a project the greater the likelihood that the project would be staffed with more personnel.

In summary, the observed staffing variations were a result of:

1. The sequence of construction progress—where this sequence was altered to include the essential formation of more than one project.
2. The physical proximity of work to other work.
3. The detailed knowledge of, and responsibility for, more than one job by a senior project supervisor.
4. The level of seasonal personnel when compared to the number of permanent personnel assigned to the same job.

Other staffing variations occurred. These were often inexplicable and apparently grew from such things as a lack of useful work to be performed elsewhere and contractor scheduling problems.

Historical Analyses

The primary result of the historical analyses was the establishment of a normal allowable calendar day's construction time by type of improvement. As previously noted, programming procedures established a date for commencing contract work for the coming three-year period. Completion dates were not scheduled. This procedure prohibited the establishment of effective construction manpower scheduling procedures.

Table 1 gives the normal calendar time allowance for each improvement type. These allowances were the results of detailed analysis of several projects for each improvement type. Extraordinary circumstances were excluded from the data that were averaged to obtain the normal allowance.

Construction engineering and inspection cost variations were substantiated for similar jobs. Again, care was exercised to exclude projects that were constructed under unusual conditions and to insure that the projects were comparable. Figure 6 is an example of one of these analyses. As can be seen in this figure, construction engineering and inspection costs did vary for similar projects. Cost variations could not be attributed to construction time.

TABLE 1

TYPES OF IMPROVEMENTS AND CONSTRUCTION TIME

Code	Type of Improvement (project)	Calendar Days per Construction Mile
10	Grade and aggregate surface	16.5
11	Grade and bituminous-treated base	16.5
12	Bituminous-treated base and plant-mix base	8.5
13	Intermediate type surface	8.5
14	Widening	10.0
15	Widen and retread	12.0
16	Selective grading and widening	12.0
20	Surfacing all stages	8.2
30	Structural	
	Box culverts	40.0
	All other structures	100.0
31	Grading[a]	35.00
32	Surfacing[a]	
	Portland cement concrete	12.0
	Asphaltic concrete—shoulders, ramps, etc.	20.0
33	Signing[a]	5.0
35	Grading—4 lane added	16.5
36	Bituminous-treated base—4 lane added	8.5
37	Surfacing stage 1—4 lane added	8.2
38	Surfacing stage 2—4 lane added	8.2
39	Surfacing stage 3—4 lane added	8.2
40	Surfacing ultimate—4 lane added	8.2

[a]Normally used for Interstate projects only.

Staffing Standards

The work observations and historical analyses indicated that improvement types (projects) were sufficiently similar to make feasible the establishment of standard levels of staffing. Figure 7 is an example of one of these standards. It was developed by the project staff and Construction Manpower Committee. Similar standards were developed for each of the 18 improvement types and approved by top management.

The standard defines how many men are normally required by project type, and whether those men should be temporary or permanent employees.

Some work activities require less than full-time attention. In these cases, the minimum manpower requirement recognized in the standard was one-half time for one man. The less than full-time personnel requirements will be filled by trade-offs, that is, by one man performing two or more part-time activities, or by the temporary transfer of personnel from other projects.

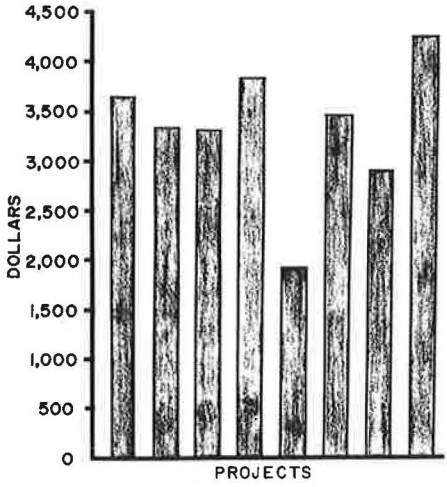

Figure 6. Grading construction engineering cost per mile 1965-1966.

The staffing standard presumes that each project stands alone. The physical proximity of projects will influence staffing requirements. These factors are weighed during scheduling of personnel; however, the standard provides a basis on which these decisions may be made.

The staffing standard provides definition of the "mix" of employees that will be required by personnel classification. This was accomplished by relating the knowledge, skills, and abilities required to fulfill effectively each of the major activities, together with the personnel classification structure now in effect in North Dakota. The classification plan is based on the same criteria as is the staffing standard. Emphasis in both was placed on employee flexibility and well-rounded knowledge of the jobs to be performed in construction inspection.

	Number of Personnel		
	Permanent	Temporary	Total
Supervisor	1		1
Survey Crew	2	2	4
Lab. Man	1		1
General Inspector-Compaction	1		1
Pipe and Structural Inspector		½	½
Water Checker		½	½
Scale Man		½	½
Gravel Checker		½	½
Office Man	1		1
Seeding-Sodding Inspector		½	½
	6	4½	10½
Permanent by Classification:			
Project Supervisor	1		
Technician III	1		
Technicians II	4		

Figure 7. Staffing standard, grade and aggregate surface.

Normal vehicle requirements were also anticipated in the staffing standard. Vehicle assignments were based on three primary factors: (a) the need to be able to transport personnel to the job, (b) the need for certain personnel to be mobile in the discharge of their duties, and (c) the size and vehicle specialization that is required to transport certain testing and measuring equipment. As with the manpower standard, the vehicle standard anticipates trade-offs and less than full-time vehicle utilization.

CONCLUSIONS

The principal conclusions of the study are as follows:

1. Adequately trained construction engineering and inspection personnel are a scarce, vital resource. Increases in the level of employment require lead time so that capable personnel may be recruited and trained. The job knowledges and skills that are required are extensive.
2. Relatively long-range manpower planning and short-range scheduling of personnel is as important as is the planning to meet highway needs. Each is dependent on the other.
3. Effective measures of control cannot be developed unless standards exist whereby day-to-day staffing levels may be evaluated.
4. Planning and scheduling of manpower must be continuous and flexible. Schedules and plans must be adjusted to meet changing field conditions and changes in priorities in the construction program.
5. Organizational structures do influence the level of construction inspection staffing. If personnel are not available on short notice to meet peak work loads, project supervisors tend to staff at peak levels each day.
6. Balanced manpower plans provide greater job stability. As such it contributes to employee morale and security, and may aid in the reduction of personnel turnover rates.
7. The manpower plan facilitates the preparation of a work-related budget. Budgetary changes may be rapidly evaluated in terms of related changes in the level of employment. This information is then readily available to provide detailed guides as to the numbers and locations of personnel who will need to be recruited.

IMPLEMENTATION

The North Dakota State Highway Department is implementing the results of this study.

Organization

The Department has created construction residencies. These residencies do not have fixed headquarters or fixed boundaries. The lines drawn between residencies, and the offices of senior personnel responsible for the residencies, are shifted to meet the workload.

The Department has appointed a full-time construction staffing officer assigned to the Construction Division. Among his duties are the preparation of manpower plans, the coordination of manpower needs between residencies and districts, the coordination of personnel recruiting and training, and the coordination of the budgetary materials.

Manpower Scheduling

Figure 8 is a map of a district. It shows the physical location of each project to be constructed in 1969. The district is divided by a line running north and south that corresponds to the authority of a senior engineer. The line is not fixed.

Figure 9 shows the project scheduling for each of the jobs to be under way in this district in 1969, together with the manpower requirements for those jobs. The first digit represents the number of permanent personnel required and the second defines the number of seasonal personnel that will be needed. (Note that personnel were not planned for projects 24-1, 7-052 and 48-2 for the West Residency in 1969. Personnel for these projects will be made available by transfers from projects completed within the residencies.)

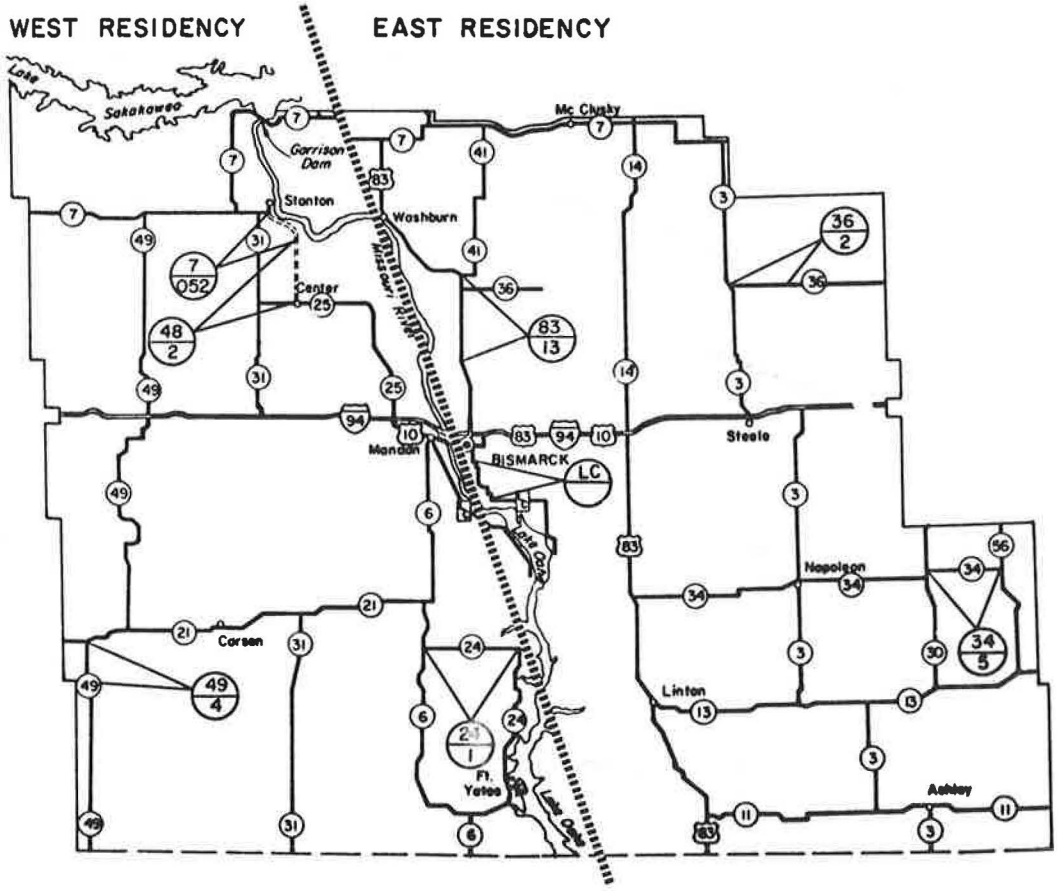

Figure 8. Map of highway district "A".

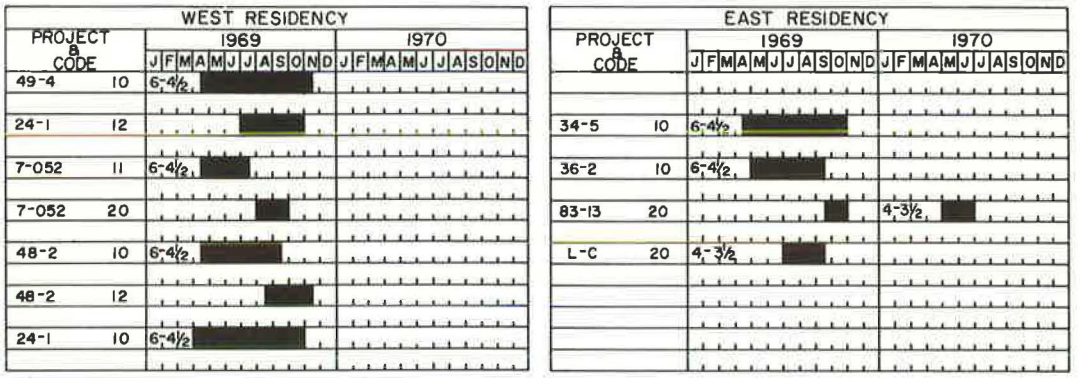

Figure 9. Scheduling projects and personnel.

Table 2 compiles the manpower and vehicle requirements to meet the construction work load planned in District A for 1969.

Statewide Application

In May 1968, the first trial manpower needs program was prepared on a statewide basis. This plan was based on a tentative 1969-1973 construction program that was not yet finalized.

The trial application covered a five-year period and showed an increase in permanent inspection personnel in 1969 that was equivalent to one-third of the existing permanent work force. This was the peak personnel demand for the coming five-year period. The application of the trial manpower needs to the tentative construction program indicated that the total field force requirement would drop from 520 employees in 1969 to 350 employees in 1973.

This information gave management a program evaluation tool that was not previously available. After re-programming, the manpower requirement leveled in total but continues to vary by district and residency.

TABLE 2

REQUIRED STAFFING OF HIGHWAY DISTRICT "A"
1969

(a) Manpower Requirements

Classification	East Residency	West Residency	District Total
Technician I	1	1	2
Technician II	8	15	25
Technician III	4	4	8
Project supervisor	3	4	7
Senior supervisor	1	1	2
Total permanent	17	25	44
Total temporary	13	18	31
Total manpower	30	43	75

(b) Vehicle Requirements

Type of Vehicle	East Residency	West Residency	District Total
Automobiles	3	4	7
Panel trucks	5	8	13
Six-passenger pickup	2	4	6
Three-passenger pickup	2	3	5
Total	12	19	31

Results to Date

As previously noted, this is but one portion of a personnel management study. Rather dramatic results have been achieved. It is not possible to say what results were obtained from each specific phase of the program. However, the following are the overall results.

The 1968 level of average monthly construction employment has been reduced by 80 employees (30 percent) from the 1967 level, whereas construction expenditures in 1968 were about 10 percent higher than 1967.

Because of the economies realized in this and other divisions, the Department has been able to implement a prevailing wage (going rate) plan while reducing the total labor expenditures.