

Use of Private Firms for Highway-Engineering Functions

HARMER E. DAVIS, Director; DONALD S. BERRY, Assistant Director; and WAYNE H. SNOWDEN, Associate Engineer, Institute of Transportation and Traffic Engineering, University of California

● INCREASING rates of highway building throughout the nation and prospects of further increases have raised a number of difficult problems in highway administration. Not the least of these problems is that of obtaining engineering personnel in sufficient numbers and with adequate experience and training.

Some highway agencies have been greatly handicapped, through inability to change salary or other personnel policies, to meet the changing situation. In some cases this has impaired their ability to undertake expanded programs. Some highway agencies, on the other hand, have so far been able to meet the problem by establishing salary scales reasonably competitive with those of industry and other agencies or by providing collateral inducements, such as attractive retirement plans. Still others have been able to handle additional work by contracting for engineering services with private engineering firms, thus avoiding legal limitations on agency staff strengths or salary scales.

If further acceleration of highway construction should take place rapidly, it will probably be necessary to consider the total national potential of highway-engineering manpower, regardless of whether it is employed in highway agencies or acquired through the services of private engineering firms. The total pool of experienced professional engineering manpower is limited and seems likely to remain so for years to come. Hence, merely to shift engineers from one state to another or from public to private employ, or vice versa, appears to offer no satisfactory overall solution to the manpower problem. Rather, the overall solution will probably have to be attained by a combination of several devices. One might be to give closer attention to relieving professional highway engineers of non-engineering administrative duties. Another might be to make increased use of personnel in vocational grades for work such as drafting and computing. Still another might be to give increasing attention to standardized design procedures to

the extent that possibly these might serve to reduce hours of engineering required per unit of construction. These, rather than shifts of personnel from place to place, or manner of employment, appear to be the kind of approaches which would be mandatory in the face of a critical highway engineering manpower shortage, nationwide.

The possibility of this sort of nationwide difficulty argues for close examination of highway engineering personnel practices, including practices in the use of private engineering firms. The latter, however, is of interest in other respects. A given organization finds a variety of situations, differing in nature, degree, and duration, requiring administrative decision as to what steps should be taken to accomplish engineering work which lies immediately ahead. It is in this latter connection that this study of practices in the use of private engineering services may be of most-immediate general use.

OUTLINE OF STUDY

This study has been concerned mainly with that area of engineering activity which comes after broad preliminary or top-level planning. Generally excluded, therefore, are practices as to the use of consultants to render special advisory and review services on difficult projects, to perform highway needs studies, and to make independent feasibility analyses for revenue-bond projects, such as toll roads.

The attention in this study has been directed primarily toward the practices of state highway departments, although some inquiry was made of practices of two turnpike agencies, two large federal constructing agencies, a railroad company, a public-utility company, and a petroleum company. The practices of highway agencies of local jurisdictions were not included in this study.

The information for the study was obtained by questionnaires received from 44 states, by additional correspondence and

interview with highway officials in a number of selected states, by interview with a number of consulting engineers and groups of consultants, and by interviews with engineering administrators of the nonhighway agencies included in the study.

GENERAL PATTERN OF USE OF PRIVATE ENGINEERING SERVICES

From the responses of 44 state highway departments, it was found that about 80 percent of the departments use the services of private engineering firms to some extent. For those of the 80 percent who indicated the extent to which they made use of private engineering services, the range was from as little as 1 percent to as much as 25 percent of the volume of construction in a given year.

Except for advisory or review services, or for independent appraisal and feasibility studies, the types of service for which highway departments have employed private engineering functions may be grouped principally as follows: (1) preparation of plans and specifications, supplementing the same kind of work by the department staff, and (2) performance of specialized work.

Supplementary work on plans and specifications has been confined to peak periods, for which the department did not consider it feasible to add temporary staff, or for which it could not acquire staff because of legal limitations, salary offered, or time. Specialized work, on the other hand, has been let to consultants in both peak and nonpeak periods in cases where the department has not considered it feasible to develop the specialty internally, either because it was an isolated case or, although recurrent, constituted a relatively small workload.

Generally (except for toll-road projects), state highway departments do not contract for the services of private engineering firms to perform simultaneously all the engineering functions associated with the planning, design, and construction of a highway project. The principal use of private firms (as a supplement to normal staff) has been for final design and the preparation of drawings and specifications for construction. Preliminary planning is occasionally given to consultants, but the supervision of construction is only rarely handled by contract with consultants. Many states now contract with outside firms for

the preparation of topographic maps for reconnaissance, by aerial photography. Negotiations for rights-of-way are normally handled by agents of the state department, although in a few states experts from the outside are occasionally brought in to make appraisals and to prepare property descriptions. In the construction of toll roads, either under the jurisdiction of a highway department or under a separate state authority, private firms have performed the major portion of the engineering work.

The reason most-frequently reported by state highway departments for engaging private firms was to handle peak loads. The second-most-frequently reported reason was that the engineering service desired was special with respect to most of the engineering ordinarily performed by the department's staff.

A summary of the types of engineering work performed by consultants for 35 state highway departments and the District of Columbia, excluding services in connection with toll-road projects, is given in Table 1.

COSTS AND SELECTION

Based on data from 15 states, consultant's fees for final design and the preparation of plans and specifications for bridges and roadways range from 2 to 5 percent of the cost of construction; the size of the fee depends upon the size and complexity of the project and on the amount of data furnished to the consultant by the contracting agency. In the majority of cases studied, these fees do not include advance planning or supervision of construction. A summary of fee data reported by the states is given in Table 2.

To compare the cost of doing work by a highway department with its own forces and the cost of doing the same work through the employment of private engineering firms is a difficult matter. Generally, highway departments, as public agencies, are required to do their accounting under rules established through law or by the legal fiscal agent or department of the state government. Such fiscal accounting for legal purposes does not meet the same requirements or provide the same breakdowns of accounts as the kind of cost accounting which would be done for technical cost control or comparisons. Lacking a basis for precise comparison of costs, opinions were obtained via the question-

TABLE 1
TYPES OF ENGINEERING PERFORMED FOR STATE HIGHWAY DEPARTMENTS
BY PRIVATE FIRMS
(Including the District of Columbia. Excluding work on toll roads.)

State ^a	Topo- graphic maps ^b	Prelimi- nary route surveys	Foundation studies, material surveys	Roadway design, plans, specs.	Bridge design, plans, specs.	Super- vision of construc- tion	Other
Arkansas							X
California	X						X
Colorado					X		
Delaware			X	X	X		
Georgia					X		
Idaho	X			X			
Illinois		X	X	X	X		
Indiana				X	X		
Iowa		X		X	X		
Kansas				X ^c	X ^c		
Kentucky	X			X	X		
Louisiana	X		X	X	X		
Maine		X		X	X	X	X ^d
Massachusetts	X	X	X	X	X		
Michigan	X			X	X		X ^e
Minnesota					X		
Mississippi			X				
Missouri				X	X		X ^f
Nebraska	X	X		X	X	X	X ^f
New Mexico				X	X		
New York	X	X	X	X	X	X ^c	X
North Dakota				X	X		
Ohio		X		X	X		
Oklahoma				X			
Pennsylvania	X	X	X	X	X		
Rhode Island	X	X	X	X	X	X	
South Carolina					X		
South Dakota		X	X	X			
Tennessee					X		
Texas	X						X ^d
Vermont		X		X	X		
Virginia	X	X	X	X	X		
Washington	X	X					
West Virginia	X	X			X		
Wisconsin				X	X		
Dist. of Columbia	X	X	X	X	X		

a. The following states reported not using consultants: Arizona, Montana, Nevada, New Hampshire, Oregon, and Wyoming.

b. Confined in some cases to aerial surveys; a few states listed under ^a reported aerial surveys but did not consider them engineering.

c. Urban only.

d. Unusual structures such as tunnels

e. Water-main and electrical work on expressways.

f. Materials testing.

TABLE 2
FEES FOR CONSULTING SERVICES

State or Agency	Fees*	Remarks
Colorado	Avg 5 0 - Bridges Only	Fee is for design of bridges only. Bridges not too large. Fee includes preliminary report but does not include topographic surveying, nor foundation and materials surveys.
Illinois	4.0 - Roadways 4.0 - 4 5 - Bridges	Fee is established by highway department and is for design. Consultant is furnished all basic data necessary for design.
Indiana	1.85 - 3.15 - Roadways 2.4 - 5 0 - Bridges	Fee is for design. Consultant is furnished topographic surveys and foundation and materials investigations, but is required to do a certain amount of surveying
Kansas	3.25 - 3 50	Fee is for design of roadway and bridges and includes preliminary report Consultant furnished all basic data in the form of topographic surveys, foundation and materials investigations, location, etc.
Maine	Avg 4.0	Fee is for design of roadway and bridges. Consultant is furnished most of the basic data
Michigan	Avg. 4 0	Fee is for design of bridges principally Consultant is furnished all basic data required for design
New Mexico	2.5 - 4.0	Fee is for design of roadway and bridges. In most cases consultant is furnished all basic data required for design Where he is asked to furnish some of the basic data, the fee is nearer to 4 percent.
Ohio	2.75 - 3 60	Fee includes not only design but also preliminary projects reports Preliminary project report represents small fraction of fee. Consultant required to make instrument surveys for design. Fee does not include the actual making of borings but does include analysis of results.
Pennsylvania	2.75 - 3 50 - Roadways, including Bridges	Fee is for design primarily. Consultant is required to perform a certain amount of instrument surveys Fee does not include preliminary report which is contracted for separately.
South Dakota	Avg. 3 4	Fee is for design of roadways and drainage structures Consultants normally furnished data on borings, is required to make instrument surveys, but this is a minor item in South Dakota.
Tennessee	2 75 - 3.85	Fee is for design of bridges only Consultant is furnished all basic data required for design
Vermont	3.0 - 3.5	For design of roadways and bridges Consultant furnished data on materials and foundations, topography, etc Fee has also been expressed in terms of per mile as follows urban projects \$5000 to \$9000 per mile, rural projects \$2500 to \$4000 per mile.

Note Design includes preparation of plans and specifications

* Percentage of Construction Cost

naires from the officials of 28 states; about 80 percent said they thought it cost more to have the work performed by outside firms, 10 percent that it cost less, and 10 percent that the costs were about the same.

Contracts for engineering services are closely analogous to those for construction. Like construction contracts, they are generally designated by the method used in arriving at the amount of the compensation. The types of engineering contracts in common use for highway work are as follows:

1. Fee based on a percentage of the actual or estimated construction cost. Normally the fee is based on the actual construction cost; if, however, the construction is postponed or cancelled, the fee is based on the estimated cost of construction.

2. Lump-sum fee. Usually the fee is based on a percentage of the estimated con-

struction cost or based upon an estimate of the engineering costs plus an allowance to cover the engineer's profit and overhead.

3. Cost of providing the engineering service plus a fee. The fee may be a fixed sum or a percentage of the cost. In this type of contract, the cost is usually regarded as engineering salaries plus other out-of-pocket expenses—excluded is overhead like clerical, rent, etc.

4. Fee based on a time rate. The unit of time commonly used is the calendar day.

5. Other methods of payment, such as a fee per mile of roadway, are used occasionally.

For design and the preparation of plans and specifications about half of the public agencies require that the contracts be drawn up on a lump-sum basis, while the other half permit the fee to be based on a per-

centage of the estimated or actual construction costs. The cost-plus-fee type of contract is used only occasionally for the preparation of plans and specifications.

For preliminary project reports the lump-sum type of contract is prevalent.

For items such as foundation and materials investigations, where costs in advance cannot be accurately determined, the cost-plus-fee type of contract seems to be favored. In a majority of the cases the fee is expressed as a percentage of the salary costs.

Contracts for consulting services in highway work almost always include a non-raiding clause prohibiting the consultant from hiring highway-department personnel during the time that the consultant is performing work under the contract.

A consultant is usually selected on the basis of an appraisal of his competence and capacity for the particular type of work proposed. Some agencies develop a panel of consultants considered to be generally competent, and final selection is made after detailed conferences with available consultants included in the panel. Agreements with respect to fees are usually arrived at by negotiation. Some agencies have called for competitive bids for engineering services, which practice has raised a number of difficult questions as yet unresolved.

PRACTICES OF NONHIGHWAY AGENCIES

Federal Agencies

Selected districts of two federal agencies were interviewed during the course of this study; these differed to some extent in their use of consulting firms. A district of the Corps of Engineers uses consultants only for the preparation of plans and specifications for construction. All of the work concerned with preliminary planning, materials and foundation surveys, and supervision of construction is performed by the district's own forces.

On the other hand, a district of the Bureau of Yards and Docks utilizes consulting firms not only for the preparation of plans and specifications for construction but also for advance planning, although the use of consultants for the former purpose is by far the most predominant. The districts of the Bureau of Yards and Docks do not use consulting firms for supervision of construction, and only occasionally do they

use them for foundation and materials investigations.

Both agencies use their own forces to acquire rights of way.

Industries

The surveyed industries have made extensive use of private engineering services for many years. Two reported that consulting services accounted for about 25 percent of the engineering handled by the organizations' central engineering staffs and one reported 3 percent. The two reporting the higher figure have been engaged in rapid plant expansion, at a rate higher than expansion of the highway plant.

These industries also report using consultants to handle peaks and to do specialized work, the first accounting for by far the greatest number of man-hours turned over to private firms. By peaks, these industries mean engineering work loads which lie above forecast staff capabilities, which cannot be deferred, and which do not seem to guarantee a 3- or 4-year staff position (a position lasting that long is assumed to be guaranteed indefinitely by staff attrition). Specialties are regarded as types of engineering which would not require the full-time attention of more than a few men and which would therefore limit staff flexibility if established internally.

It is not uncommon in industrial practice to assign all engineering of a project, excluding broad preliminary planning but including supervision of construction, to a consulting firm. This is usually done only when the same engineering firm is the construction contractor. The surveyed railroad, however, uses consultants only for specialized engineering and for preliminary design, all detailed plans and specifications being prepared by its own forces.

CONCLUDING COMMENTS

Practices in the use of private engineering firms for the performance of certain highway engineering functions show certain common features. They also raise important policy questions. Some of these questions require answers as an every-day matter of efficient highway administration. Others come into prominence whenever a particular organization faces the prospect of a greatly accelerated construction pro-

gram. Still others will demand study and resolution if accelerated highway construction becomes nationwide. Among the questions requiring attention, two have been made apparent in this study:

1. Costs

One surveyed industry maintaining exceptionally detailed cost information reported that (1) engineering by consultants in its field of activity cost considerably more than it would cost to do the same engineering internally if staff were available and (2) the organization makes extensive use of consultants continuously. The seeming paradox is explained by consideration of other cost factors associated with hiring and firing, training, and miscellaneous overhead, not to mention factors which, while they cannot be precisely costed, must have some theoretical dollar value, such as morale. This example makes it plain that costs must be carefully analyzed in their application to engineering personnel planning. The accounting procedures usually required of highway departments by law seldom permit cost analyses according to engineering functions. This study emphasizes the need for

cost data, which will make such analyses possible.

2. Increasing the Total Manpower Pool

A greatly augmented program of highway construction will require manpower which will not necessarily be provided through pooling the engineering personnel of public agencies and private organizations. It would appear, however, that by conserving professional engineering personnel for performance of the professional aspects of the work and by training a sufficient body of supporting technician-type personnel, such as draftsmen, computers, and inspectors, a total manpower potential could be developed adequate for the demands now in prospect. Steps in these directions undoubtedly would, in many cases, require changes in methods of organization and pose new problems in job analysis. They are, however, steps that appear deserving of most careful study.

ACKNOWLEDGMENT

The authors wish to acknowledge with thanks the wholehearted and valuable collaboration of their colleagues, Robert Horonjeff and W. Norman Kennedy, on a number of phases of this study.