A Study of Local Road Administration and Engineering Manpower

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● THE engineering manpower situation has given impetus to studies centered on local road agencies, as it has to practically all aspects of engineering. As a result the general nature of local studies, as carried out in California were discussed (1) at the 1956 annual meeting of the Highway Research Board.

The shortage of engineers tends to concentrate such studies on immediate means of increasing availability and productivity of the technical working force. The increase of productivity, at least, is a desirable long-term objective. Nevertheless, regardless of the circumstances that give rise to these studies, the studies deal with one or more phases of engineering administration and thus provide opportunity for developing a better understanding of road management, to which current manpower availability is more or less incidental.

Studies of engineering manpower in California county road departments have been conducted with these dual purposes of immediate and long-term usefulness. This paper presents, specifically, information about the numbers of technical personnel per unit of construction and about jobs filled in relation to salaries paid in California county road departments. More generally, however, it is intended to deal with some features of finding and reporting facts about local road administration, and to discuss some fundamentals of the engineering manpower situation which are often passed over, especially in the present atmosphere of concentration on immediate corrective measures.

Considerable information about engineering manpower in California county road departments has been gathered by both the California State Division of Highways and the Institute of Transportation and Traffic Engineering, University of California. This work began in 1955 and is continuing. Most of the information is of a statistical nature; that is, it concerns numbers of individuals, amounts of salary, etc., rather than how individuals behave or what they say and think. Being of this nature, it avoids many of the problems in psychology and semantics that are so common and so perplexing to students of administration.

This is not, however, to say that it avoids all of them. And both because those that remain are likely to be slighted by investigators who incline to the engineering point of view, and because these remaining problems place special importance on how findings are reported, they are referred to first.

NATURE OF ADMINISTRATIVE FACTS

Administrative facts of the type here considered, however quantitative, are of a different order than facts of nature, however qualitative. Administration is concerned with organizing and guiding human effort. The study of administration is concerned with evaluating, and presumably influencing, this organizing and guiding activity, which is itself a human effort. Some aspects of administration can be numerically expressed. A county road department may have 15 authorized engineering positions—something that can be recorded, tabulated, added, and generally handled as a number. But the number conceals a history of law and custom, an environment of human intention, past and present, which make it what it is today and may make it something else tomorrow. It is by no means of the same class as a number representing the density of a soil.

There is a temptation, however, to attribute to administrative numbers a sort of natural validity that they do not have and to overlook the human connotations that they do. Especially is there a disposition to regard an average of such numbers as acquiring a validity not present in the humbers from which it was derived, much as if human vagarie were a random distribution around some desirable mean. The possibility of these humar

connotations attaching to numbers developed in administrative studies should keep everyone on guard against definite statements of correlation, which, however impressive in mathematical expression, may rest on a relationship that, functionally, is tenuous or even non-existent.

REPORTING OF ADMINISTRATIVE FACTS

An even more important consideration may be the manner in which administrative studies become useful. The soil density, already selected for example, may be fed into scientific channels of communication with assurance that it will be dispassionately extracted and directly utilized by anyone having need of it. The results of administrative study, however, are primarily useful to the administrations they to some extent portray, and they are useful, not as independent facts on which to base a new design, but as guides by which the administrations may alter themselves. In such a situation it is unrealistic to expect a neutral view of administrative findings by the very individuals to whom the findings may have some use.

These general considerations are especially relevant to the study of local road administration. The larger an organization, the more it assumes an abstract pattern that can be viewed without reference to individuals. A large organization often can create the means of looking at itself objectively, and examine and correct its shortcomings without proclaiming them to the public at large. County road departments, however, are in the main so small that a collection of particular individuals, rather than an abstract pattern, is the explanation of its administration—a situation that severely limits an organization's capacity for objective self-appraisal. This limitation, in fact, is one major reason for the collective study of county road administrations by external agencies. But external study normally makes information available to anyone who wishes to look at it, and unless findings about local road administration are presented with considerable care they are all too likely to be taken as representing a great deal more than they actually do, to become the vehicle for unfounded conclusions about a particular agency, and in general to do more harm than good.

This danger applies to the comparatively simple matter of the engineering manpower situation. To illustrate, there is the actual case of a county with a staff of 48 engineers and another county with a higher rate of annual road construction, but with a staff of only 2 engineers. The first county reports several positions vacant, over and above the 48. The second county reports all two authorized positions filled. From this bit of information, one could draw various and conflicting conclusions about the manpower situation, according to the assumption from which he proceeded. Merely to identify the agencies with special reference to these numbers would be to place one or both in the position of having to defend themselves against questions to which there are no real answers so far.

The difficulty here emphasized is that there is not a sound, or even a roughly agreed upon basis for measuring engineering manpower requirements. What is the optimum number of engineers for doing a given kind and amount of road work? What does the organization stand to lose as it departs one way or the other from this optimum number? How is the value in the roadway plant measured and up to what point is this value enhanced by additional engineering?

The objection might be raised that although specific answers cannot be given to the questions as stated, usable guides to manpower requirements can nevertheless be derived from current practice as a whole. After all, according to this objection, the nation is continuously engaged in a tremendous amount of roadbuilding, and this is being accomplished with an ascertainable amount of engineering effort, whether optimum or otherwise. Hence, it can be said that so much construction takes so much engineering and in this way engineering needs are expressed on a unit-of-construction base.

Useful as this may be for broad appraisal, it does not solve the question of how to report findings at the local level, as another example may indicate. Data obtained by the California State Division of Highways show that California county road departments, taken together, had on the job, per million dollars of construction in 1956, about 4

registered civil engineers, 4 non-registered engineers, 14 assistant and junior engineers, and 10 engineering aids. According to broad-based measures, this might be considered enough. Yet such over-all appraisal would be neither consoling nor useful to the large number of California counties that now have work waiting for engineers and technicians that they are unable to lure onto the payroll. Nor can it be said that the better-staffed counties do not need every engineer they have.

As one considers the curiosities of administrative facts, the ways in which these facts may be bent to certain purposes, and—in the current engineering manpower situation—the dearth of information on some very fundamental matters, the question of just what is being found out, and why, is brought into prominence.

CURRENT REPORTING IN CALIFORNIA

As has been mentioned, the attempt in California has been to develop fundamental information at the same time that facts about the current situation have been collected. In reporting findings, the attempt has been to challenge the thinking of all concerned with local road administration, and to do so without exposing any agency to criticism which would certainly not be justified on the basis of facts now known—with the possible exception of the fact that a good many county road departments are offering salaries far below the going wage for the class of technical personnel they are trying to attract.

It is, of course, impossible to accommodate all the foregoing considerations in selecting a given reporting method. In the California work, statistical refinement has been sacrificed, perhaps at the risk of criticism for grouping and averaging numbers, in order to present certain pictures of county road administration in a way that it is hoped will be understandable and thought provoking to the most people concerned, and to do so without arousing irrational criticism of the agencies reported on.

Data so far available permit two somewhat unrelated statements. One is of the numbers of engineers in California county road departments per unit of annual construction. The other is a comparison of salaries and engineering jobs open. Both are presented by groups of counties, the groups being made up of counties ranked according to annual rate of road construction. The reasons for resorting to such grouping were several. In the first place, California counties run through an 80-to-1 range of sizes, if size is measured by annual rate of road construction in dollars. Size is to some extent correlated with factors such as degree of urbanization, population, and population density, all of which bear on the kind of road system with which the county road department is concerned. Grouping by size should retain distinctions associated with size, while tending to average out other variations which, when counties are taken individually, frequently obscure central tendencies of some importance. Grouping also reduces the number of reported bits of information, and while this may obscure some relationships which might be discerned in the basic data, it facilitates quick general comparisons which may very well be the most useful, as well as all that can be justified on the basis of data so far available. And finally, grouping eliminates strict county-by-county comparison, thus forestalling conclusions about engineering in a particular county which might be suggested by a more detailed presentation, but which would actually not be warranted without evaluation of many factors which in the present state of knowledge are unstudied.

California's 57 counties (excluding San Francisco because it is a combined city-county) have been grouped as shown in Table 1. This grouping, which is based on annual rates of road construction expressed in round numbers, happily sets aside (in Group I) California's two unusually large counties, while producing four remaining groups of somewhat the same numbers of counties.

DISTRIBUTION OF ENGINEERING PERSONNEL

Numbers of engineering personnel engaged in work connected with construction (that is, less the numbers equivalent to time spent on maintenance, right-of-way, and non-engineering activities) were computed for each of these county groups. The results are shown in Figure 1, which gives the numbers of engineers per million dollars of

TABLE 1

GROUPING OF CALIFORNIA COUNTIES FOR STUDY OF ROAD ADMINISTRATION

Group	Millions of Dollars of Road Construction per Year[1]		Number of Counties in Group
	Per County	Group Total	
I	Over 2	11.016	2
II	1 to 2	11.344	9
III	½ to 1	10.979	16
IV	¼ to ½	5.192	14
V	Under ¼	2.168	16

[1] Average for fiscal years 1953-4 and 1954-5 as reported to the California State Comptroller.

construction for each county group. At the same time, the areas of the bars, portray the distribution of engineering personnel among the 57 counties. Although the latter serves to emphasize where engineering personnel are located, and hence to aid in evaluating county-by-county reports of shortages, it is the numbers at work per unit of construction that calls attention to more fundamental questions of engineering manpower utilization.

Why should the Group II counties (with annual construction programs ranging from $1 million to $2 million) have on a unit of construction basis less than one-third as many engineers as the counties in Group I, less than one-half as many as the counties in Group V, and for that matter less than any other group? Immediately one looks for reasons to explain away this seemingly odd situation. The first fact is that the two large counties in Group I are contending with extensive urbanization and engaged in major construction of highways to accommodate heavy traffic. It is concluded that, dollar for dollar, they must have to put more engineering time than other counties into such things as preliminary planning, utility relocation, and the design of complicated structures. A look at the Group V counties (with annual construction programs under $250,000 per year) shows that each engineer in this group counts high on a unit-of-construction basis because the levels of construction are low. But there is still no explanation for the extreme variations here shown and for the steady trend toward more and more engineers per unit of construction as progress is made toward smaller county groups, Group I excepted.

This last is particularly amazing, because it is a common assumption, doubtless reached because of the known cases of small counties with very minimum technical staffs, that there is a consistent decline in engineering availability as counties become smaller. In California, at least, such an assumption would also correspond with need—need here being thought of in terms of the kind of structures being engineered—as there is a consistent shift in road system standards as the counties become smaller, the smaller counties (in terms of construction dollars) being so, not because they are geographically small, but because they are most rural and least developed.

Whatever the reasons for the peculiar shape of Figure 1, it cannot be explained in terms either of engineering time put into maintenance or of outside engineering

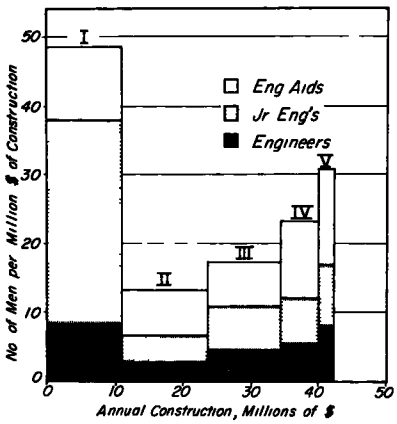

Figure 1. Distribution of engineering personnel among California county road departments-counties arranged in five groups ranked according to annual rate of road construction. Areas in the diagram are proportional to numbers of individuals.

services performed for the counties. The first is excluded from Figure 1, as already mentioned. The second has been separately examined in reports of California counties covering engineering services performed for them by the State Division of Highways and by private firms, and the total engineering accomplished in this way does not at all change the picture.

TABLE 2

PERCENT JOBS FILLED AND SALARIES IN CALIFORNIA COUNTY ROAD DEPARTMENTS

County Group	No. of Positions	No. of Vacancies	Percent Vacancies	Percent Filled	Average Salary[1]
		(a) Senior Engineering Grades[2]			
I	106	14	13	87	675
II	38	7	18	82	620
III	41	7	17	83	640
IV	23	3	13	87	655
V	19	3	16	84	580
		(b) Junior Engineering Grades[3]			
I	133	18	14	86	500
II	36	16	40	60	470
III	70	17	24	76	450
IV	11	4	36	64	438
V	10	5	50	50	426
		(c) Technician Grades[4]			
I	410	32	8	92	431
II	124	4	3	97	402
III	144	21	15	85	395
IV	57	15	26	74	331
V	46	7	15	85	378

[1] Per month. [2] 261 positions. [3] 320 positions. [4] 860 positions.

As Figure 1 is viewed as a whole—as representing engineering in a large aggregate of county road systems—it is hard to escape the conclusion that, whatever the shortcomings in visualization, one is looking at an unreasonable distribution of engineering personnel.

POSITION VACANCIES AND SALARIES

A second matter examined on the same group basis in California has been the relation between jobs open and salaries. Here the relation of manpower to construction level is ignored. Authorized positions are taken as the basis, percent vacancies are computed, and these percent vacancies are compared with salaries. The results are given in Table 2.

The average salary for a given grade level in a given county was taken as the payroll for that level divided by the number of individuals. For a county group, the average salary as tabulated is the unweighted, arithmetic mean of the individual county averages. This process leaves something to be desired as a statistical procedure, and further, starting salary rather than average for the grade may be the more decisive influence in filling vacancies. Therefore, information is now being collected on first-step salaries for jobs filled and on salaries being offered for jobs not filled. So far, however, it appears that although this latter form of reporting may serve to avoid criticism, and will certainly reduce the absolute size of the stated salaries, it

will not significantly affect the relationships here shown, because of the very close correlation between a starting or step-one salary and the average actually being paid.

The relationship is not clear in rank correlations of percent jobs filled against salary for counties taken as individual units, probably because of the considerable number of counties in which there is only one position in a given grade, with the result that the position must appear as either zero or 100 percent filled. In the grouped data, however, not only is there a general salary decline from large to small counties, as might be expected, but more importantly there are many cases in which both salaries and positions filled move with or contrary to this general trend.

The importance of such a showing is against two rather common points of view. One is that counties are committed to a certain range of salaries because of their size. The data show three cases where this is not true even for counties taken as groups. The prevailing salaries for senior engineering positions in Group III counties are higher than those in Group II, although the counties in Group III are smaller, and the same applies to Group IV in comparison to Group III. Salary variations among individual counties of similar size cannot be seen in the grouped data, but they are sizeable and numerous, offering further evidence that various salary levels can be established, however difficult a change may seem in any individual case.

The second often-heard view is that salary offers no particular promise of holding engineering personnel in smaller counties because the salary, even if increased, would still be below salaries offered by larger agencies; in other words, it would still fail to meet the competition. The data seem to deny this. If Group I is excluded where the highest salaries in this field are found, and a move is made from one to another of the remaining groups for each of the remaining job classifications, there are nine salary changes to examine, involving twelve cases of below-maximum salaries, and in eight of these nine changes the salaries and percent jobs filled move up or down together. Perhaps the most definite indication that even a relatively small salary increase will keep technical personnel on the job is to be seen in the status of Group IV counties in comparison with the groups on either side. In the case of senior engineers, the Group IV salaries are higher than both the average salaries in the 16 somewhat larger counties of Group III and the average salaries in the 16 somewhat smaller counties of Group V, and the percent jobs filled is also higher; in the case of junior engineers Group IV salaries are intermediate and so are percent jobs filled; and in the case of technician grades Group IV salaries are lower and so are percent jobs filled.

STATUS QUO AND FURTHER STUDY

Despite the statistical shortcomings already alluded to, it is felt that the data developed so far should be promptly reported so they may help in correcting salary inequities, especially in the case of individual counties where present salaries are far below the prevailing mean for similar job classifications in organizations of similar size. At the same time, more detailed information is being obtained on this fundamental to maintaining adequate staff.

In regard to the previously discussed distribution of engineering manpower among counties, an attempt is also being made to use the information so far obtained as a guide to further study along definitely constructive lines. Here the proposal is not to attempt premature inferences about optimum engineering staff, but rather to look closely at that sizeable group of sizeable counties (Group II) where the most work is being done with the fewest relative numbers of technical personnel.

The specific information presented in this paper may, of course, be peculiar to California. It is hoped, however, that the considerations raised by these findings and these methods of presentation may stimulate attention to some neglected fundamentals of engineering manpower in local road administration.

REFERENCE

1. Local Highway Engineering Manpower: Appraisal and Action, Wayne H. Snowden, Highway Research Board Bulletin 134, p. 25, (1956).