Local Highway Engineering Manpower: Appraisal and Action

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● SINCE the summer of 1955, the Institute of Transportation and Traffic Engineering, University of California, has been devoting a portion of its effort to the problem of engineering manpower in city street and county road departments. The work includes a great deal of consultation with local officials on both recruitment and training problems and an extensive survey, now nearing completion, involving staff visits to approximately 100 cities and counties in the state.

The purpose of this paper is to report this work to the extent that either methods or results may have general application. Specific information on the California work is given first; a discussion of some general considerations which this work may suggest or illuminate then follows. The first part outlines the what and why of the Institute work, gives preliminary figures on the local manpower situation, as indicated by survey returns to date, and comments on the applicability of results. The more general discussion covers some of the peculiarities of local agencies with reference to engineering manpower and then speculates on some possibilities for collective or combined action.

IMPORTANCE OF LOCAL ENGINEERING MANPOWER

Before entering our discussion, it may be well to relate city and county roadway engineering to highway engineering manpower as a whole. Using roadway construction rates as indicators of engineering effort, we find that of total roadway construction in the United States in 1954, amounting to more than $3½ billion, 25 percent took place under city and county jurisdiction. Figures for 1955, in which construction ran some $1 billion higher, may perhaps show a lower percentage of local activity, but we should still be safe in thinking of cities and counties as accounting for one-fifth to one-fourth of all roadway engineering. A similar view is supported by taking construction needs rather than past performance as measures of engineering requirements. Automobile Manufacturers Association estimates, based on U. S. Bureau of Public Roads data, give the deficiency of local roads and streets not on state systems as 32 percent of the grand total. City and county engineering, we may conclude, will be an important part of any balanced, nationwide construction program.

MANPOWER IN CALIFORNIA

Developing an Assistance Program

Institute work on the local engineering manpower problem in California was prompted by recognition of the critical situation prevailing nationally, by the views of many local officials in California, and by appraisal of other approaches to the engineering situation throughout the country. All suggested that cities and counties were certainly not exempt from the presence or likelihood of a shortage in engineers. National surveys were indicating the dimensions of the over-all problem and held promise of giving emphasis to time-saving techniques to some extent applicable at the local level. These national programs could not, however, be expected to pinpoint the actual city-county situation in any particular area. This latter seemed to be a necessary or at least highly desirable preliminary to effective action. Such was the view in which the two California associations for cities and for counties and all key local officials questioned heartily concurred.

Several city engineers and road commissioners, together with representatives of the two associations — the County Supervisors Association of California and the League of California Cities — met with members of the Institute staff in the summer of 1955, and a first phase of study was decided upon. This consists of a survey to determine technical manpower needs and to pool opinions.

Three questions are being asked in this survey: (1) What is the technical working

force and how would it have to be increased to handle additional work? (2) What are the possibilities for increasing the engineering output from existing technical personnel? (3) What are the obstacles to getting personnel and how may they be overcome?

Before going into some details of this survey, which form the basis for most of the remaining discussion, it should be mentioned that other approaches are being made. One is an exploration of possibilities for increasing technical competence through special training programs. Here again, the approach has been through organized conference with representative road officials. The outline of a practical short course for construction inspectors has been developed with a view to trying a pilot course as a guide for whatever institutions might appropriately conduct it in California. Discussion of the manpower problem has also been scheduled for the California Street and Highway Conference, presented annually by the Institute, in which city and county officials from throughout the state participate.

Method and Extent of Survey

California has 58 counties, 56 of which each spend more than a quarter-million annually for roads. Forty-six cities also each spend more than a quarter-million annually for streets. Together, these counties and cities account for more than 85 percent of all local road and street expenditures. Their engineering forces for roads and streets range from organizations of more than 100 technical personnel down to groups of 2 or 3.

Nearly all the counties have a road department dealing solely or primarily with roads. Nearly all the cities have engineering groups to whom street work is only one part of their responsibility. A few cities design subdivision streets, other cities and counties confine their engineering on subdivisions to review of plans and inspection. Several counties pay the State Division of Highways to do the engineering on their Federal-aid roads; some do it themselves.

These assorted considerations largely governed the decision as to method and extent of survey.

If findings were to be comparable — and without comparability there would be no point in a statewide survey — it became apparent that the question "how many men?"

1.a. What was your technical working force in 1954-55, and how would it have to be increased if more funds become available (see explanation on following page):

Organization Reporting	(1) Position	(2) Number of payroll positions involved	(3) Average monthly salary	(4) Technical effort, Street and Road Work only during 1954-55, in Man Months: By own staff	(5) Staff equivalent for services by the state	(6) Staff equivalent for services by private firms	(7) Total technical effort on Streets and Roads (Cols. 4+5+6)	(8) Part of total (Col. 7) on work done at public expense	(9) Part of effort in Col. 8 on construction	(10) Part of effort in Col. 9 requiring position qualification	(11) If well-qualified men applied for work today, how many would you hire?	(12) Estimates of Additional Nee: Added needs in man-months if total funds rose 25%	(13) Added needs in man-months if total funds rose 50%
		No. of Men	$	M-M	M-M	M-M	M-M	M-M	M-M	M-M	No. of Men	M-M	M-M
(a)	"Engineer"												
(b)	Engineer Prospect												
(c)	Technical Specialist												
(d)	Construction Specialist												
(e)	Surveyor												
(f)	Draftsman												

b. If total street and road funds were increased 25% (as in Col. 12), what would you estimate as your % increase in funds for construction? _____ %

c. If total street and road funds were increased 50% (as in Col. 13), what would you estimate as your % increase in funds for construction? _____ %

d. Items b and c, and Col. (10) are based on 1954-55 construction amounting to $_____.

Figure 1. California survey question 1.

Organization reporting _____

2. a. In your organization, have you reduced (since 1950), or do you see opportunities for reducing your technical personnel requirements by means of:

Procedure	No	Have Reduced	See Opportunities
(1) Changes in organization or job classification?			
(2) Simpler right-of-way descriptions, plats?			
(3) Assignment of more right-of-way matters to realtors, etc.?			
(4) Mechanized handling of data, as for sufficiency ratings, inventories, etc.?			
(5) Aerial photography for mapping, surveying?			
(6) Short-cut surveying procedures?			
(7) Simplified drafting?			
(8) Charts, tabulations of design data?			
(9) Mechanization of earthwork computations?			
(10) Standard plans for drainage structures, small bridges?			
(11) Ready data for making quick relative cost estimates?			
(12) Short-cut methods of quality control, inspection?			
(13) Less record-keeping by technical personnel?			
(14) Simpler specifications and measures for materials?			
(15) Lump-sum instead of unit payments?			
(16) Short-cut methods of materials testing?			
(17) Aerial photography for materials location?			
(18) New procedures in foundation investigation?			
(19) Better communications or transportation?			
(20) Better cost accounting, budget control, etc.?			
(21) Other?			

b. Please indicate the specific nature of procedures marked "yes", and the extent or possible extent of manpower savings: _____

_____

_____

_____

_____

Figure 2. California survey question 2.

would have to be asked in rather complicated fashion. It seemed unlikely that the percent return on a complicated question would amount to much if asked by mail. It was estimated that staff time might permit visiting nearly all of the 102 units, thus holding

forth the prospect of a close to 85 percent sample of local engineering positions in the state. This would also provide opportunity for discussion of considerations which might be overlooked in framing a survey questionnaire. Accordingly, the survey was designed

Organization reporting_____

3. a. What -- aside from scarcity of qualified applicants -- is or would be the principal obstacle to your organization's obtaining technical personnel as needed:

	Is	Would Be
(1) Inadequate recruiting procedure	_____	_____
(2) Inability to pay sufficient starting salary .	_____	_____
(3) Insufficient career opportunity	_____	_____
(4) Unsatisfactory job classification	_____	_____
(5) Not authorized sufficient positions	_____	_____
(6) Location	_____	_____
(7) Other	_____	_____

_____

_____

b. To what classes of technical personnel (as defined for the table, item 1.a.) does the foregoing principally apply:

( ) "Civil Engineer" ( ) Technical Specialist ( ) Surveyor
( ) Engineer Prospect ( ) Construction Specialist ( ) Draftsman

c. What methods are you using or what are your suggestions for overcoming the obstacles mentioned in 3.a. above?

_____

_____

_____

_____

_____

_____

_____

_____

d. What recruiting procedure do you use?

_____

_____

_____

_____

_____

_____

Figure 3. California survey question 3.

to cover the three questions (How many? How efficient? Why can't you get them?) comprehensively and explicitly, rather than quickly and easily. While surveys of this type are generally agreed to be the bane of management everywhere, the advising city and county engineers felt that a detailed survey could be justified because information was urgently needed and could not be obtained in any simpler way. The three survey questions are shown in Figures 1, 2, and 3.

Progress to Date

The survey was begun in late summer, and all but a few of the 102 organizations had been visited by year's end. Because many of the visits were made late in the year, only 57 reports are available to date. The general reception to the survey has, however, been excellent, and a fairly complete return is anticipated. It is believed that the method and conduct of the survey will prove adequate to the purpose.

Findings to Date

A partial analysis has been made of returns to date in order to give a preliminary indication of the manpower situation at the local level. The returns are from 25 cities and 32 counties; these represent 56 percent of the number of units being surveyed, but only 29 percent of the dollar volume of city and county street and road construction in California. In other words, the current sample is unbalanced toward the smaller cities and counties. It cannot, therefore, be regarded as an accurate indication of the final results for California. It may, however, be more representative of conditions in many states than the final findings, because the units still to be reported include the unusually large cities and counties in the Los Angeles and San Francisco Bay regions.

Some of the preliminary findings are summarized in Table 1. The technical personnel being surveyed were divided into six types and labeled so as to minimize confusion with job titles, which vary from place to place. The first two are professional classifications, "engineer" being in quotes because it was not desired to confine the type to engineers registered under California law; engineer prospect in most cases covers college graduates with less than four or five years' experience. Technical specialist means an office or laboratory man doing some phase of engineering. Construction specialist generally means inspectors (if they are not engineers). Surveyor is confined to instrument man or chief of party. Draftsman applies to those who are not engaged in design (who would be classed as technical specialists). More elaborate definitions accompanied the questionnaire, but the foregoing may suffice for present purposes.

Each surveyed organization reported the man-months of staff time in 1954-55 applicable to streets and roads. These totals have been divided by 12 to obtain the first column of figures in Table 1, the equivalent full-time positions filled.

Positions vacant, shown in the next column, are on a different basis. These are the total authorized position vacancies reported in response to the question, "If well qualified men applied for work today, how many would you hire?" today being whatever day

TABLE 1

TECHNICAL MANPOWER PERSONNEL AND PERSONNEL NEEDS IN 57 CALIFORNIA CITY STREET AND COUNTY ROAD DEPARTMENTS

Type of Personnel	Equivalent Full-Time Positions			
	No. Filled	No. Vacant	% Filled	Added Number Needed for 25% More Funds
"Engineer"	96	17	85	17
Engineer Prospect	73	34	68	30
Technical Specialist	58	10	85	13
Construction Specialist	81	16	83	22
Surveyor	53	11	83	22
Draftsman	56	18	76	26

(in the latter half of 1955) each organization reported.

Although the two sets of figures are not in correspondence, a "percent filled" figure is given, based on the assumptions that present full-strength staffs would be the sum of positions filled (in 1954-55) and positions vacant (now), and that all vacancies represent full-time positions in street or road work. Despite the obvious probability of error in both assumptions, the percentages should be valid in relation to one another and serve to emphasize two major findings:

1. There is a present shortage in all classes of technical personnel at the local level.
2. There is a critical shortage of young engineers.

If the number of vacancies in this 29 percent sample were representative of conditions statewide, it would indicate that local street and road agencies in California are in immediate need of 59 "engineers" and 118 engineer prospects. To place these figures in perspective, it may be noted that to fill the indicated vacancies for engineer prospects alone would take half this year's civil engineering graduates from all accredited colleges in the state.

The last column in Table 1 shows the equivalent full-time positions represented by the local road officials' estimates of additional needs — additional, that is, to the actual man-months of engineering in 1954-55 — needs that would arise if total funds for streets and roads were increased 25 percent. (Incidentally, the reports indicate that a 25 percent increase in funds would result in about 40 percent more construction.) It is noteworthy that the shortage prevailing now is almost the same as the additional number of individuals estimated as needed to handle programs growing out of 25 percent more total funds.

A second view of the local engineering requirement is provided by the reports of actual engineering time devoted to street and road construction paid for out of the city or county treasury. This actual time was arrived at by first adding to the staff time any engineering time represented by state or private services, and then subtracting from this total any time devoted to maintenance, right of way, and subdivision and similar work. This actual time applicable to construction (not construction engineering but all phases of engineering applicable to construction projects) is shown in Table 2, converted to equivalent full-time positions and compared with the additional requirements (repeated from Table 1).

The subtotals and totals have been inserted in Table 2 to demonstrate that the figures are a great deal more reasonable than they appear at first glance. Give or take 1 percent, they simply state that 40 percent more construction is going to take 40 percent more engineers and 40 percent more total technical personnel. This is interesting because it is usually thought that a given increase in activity does not require an engineering organization to effect as large an increase in personnel. For some organizations

TABLE 2

ENGINEERING REQUIRED FOR STREET AND ROAD CONSTRUCTION IN 57 CALIFORNIA CITIES AND COUNTIES, 1954-55

Type of Personnel	Equivalent Full-Time Positions Applicable To Construction		
	Actual No. in 1954-55	Added Requirement for 25% Increase in Funds[a]	
		Number	Percent
"Engineer"	71	17	24
Engineer Prospect	49	30	61
Professional Subtotal	(120)	(47)	(39)
Technical Specialist	48	13	27
Construction Specialist	61	22	36
Surveyor	46	22	48
Draftsman	42	26	62
Total	315	130	41

[a] A 25 percent fund increase is estimated to represent a 40 percent construction increase.

TABLE 3

TECHNICAL PERSONNEL PER MILLION DOLLARS OF STREET AND ROAD CONSTRUCTION IN 57 CALIFORNIA CITIES AND COUNTIES

Type of Personnel	No. of Personnel per $1 Million of Construction	
	Actual in 1954-55	Estimated for a 40% Larger Construction Program
"Engineer"	3.3	3.0
Engineer Prospect	2.3	2.6
Technical Specialist	2.3	2.1
Construction Specialist	2.9	2.8
Surveyor	2.2	2.3
Draftsman	2.0	2.3

this is true. But the reverse is true in some local agencies in California, especially counties, a fact brought to light in the conduct of the survey. The reason is that many of these agencies are now doing a considerable amount of construction with their own forces. An appreciable increase in construction would have to be accomplished through contract, resulting in a disproportionate increase in engineering.

Table 3 shows numbers of personnel, by type, required per million dollars of construction, the first column applying to the actual 1954-55 activity and the second to a 40 percent higher level of construction with the estimated additional personnel included. The first column was obtained by taking 1954-55 engineering and the construction expenditures in the same year. While much of the engineering in a given year is of course applicable to construction occurring in a later year, it is believed that this consideration is immaterial when these 57 surveyed organizations are considered as a group.

To summarize, then, findings to date indicate that local roadway agencies (1) face engineering manpower problems similar to those in larger organizations, (2) are presently in need of all types of personnel, (3) are critically in need of junior engineers, and (4) will need additional technical manpower in proportion to additional construction.

Usefulness

The nature and preliminary findings of this particular survey have been detailed to the extent that they may throw light on the local engineering manpower situation in general or be of use in detailed appraisal elsewhere. But we are really concerned with solving a recognized problem. We are coming to that. But first let us note that appraisal need not be a separate exercise in fact finding. The survey just described was designed to lead directly into corrective action. Here are some of the ways it may do so:

1. The fact of the survey's being made detailed rather than cursory, thus compelling more attention, may stimulate thinking and action in individual participating agencies.
2. The inclusion of a check list of time-saving procedures (Figure 2) forces attention to the possibility of their immediate application.
3. By visiting the agencies surveyed, the Institute has incidentally acquired information which would not have been obtained on paper and which is already influencing its other activities of service to city and county roadway engineering departments.
4. Final results of the survey will be promptly forwarded to participating agencies and other groups capable of influencing engineering manpower in cities and counties. This should (a) provide concrete facts which may assist city and county engineers in substantiating proposals for corrective measures as may be required in a particular locality, such as better salaries, authorization of positions, reclassification of jobs, or other factors affecting the hiring and keeping of technical personnel, (b) convey a picture of the situation to individuals on policy-making levels who can initiate general measures to alleviate the problem, and (c) provide the Institute staff conducting the survey with facts which can be directly communicated to the appropriate groups capable of effective action.

GENERAL PROBLEMS

The Over-All Shortage of Engineers

From one point of view, cities and counties are in the same boat as everybody else. They cannot get out until the boat lands, which is to say until there enough technical personnel to go around. This objective can be realized only by reducing the need for personnel or increasing the number available or both. Most local organizations seem to feel that they can do neither. As to reducing need, many say, they are either committed to the status quo, already so streamlined that possibilities of further improvement are trivial, or so small that time-saving techniques are inapplicable. As to increasing the number available, they say, that is a problem for somebody else. But the fact is that many local organizations are both reducing the need and increasing the number, and it appears that many others could do likewise.

Reducing the Requirement. The possibilities of better utilization of technical manpower were explored in the Institute survey by a question (Figure 2) listing specific procedures and asking whether these have been used effectively or hold promise of reducing technical manpower needs. Analysis of these reports has not been completed, but numerous examples have been found in which an organization feels that it could gain nothing by a particular procedure, whereas another organization, comparable to the first for all practical purposes, has used the procedure and definitely effected savings in engineering time.

The difficulty here appears to be that the lagging organizations are simply not fully informed. A solution would be to inform them. To a limited extent this is being accomplished by current surveys and reports that give emphasis to time-saving procedures. It is aided by the technical press, both commercial and professional. But the need seems to be for making sure that this information gets to the places where it can be used and is presented not as an interesting event occurring elsewhere but as a procedure having possibilities for immediate application. Many agencies are communicating in some way with cities and counties. A contribution could come from each.

There seems to be a general feeling that in view of what is now conventionally termed the critical engineering shortage, time-saving is a comparatively minor matter. But let's take an example. Suppose 30 percent more engineers are needed, or 130 percent of the present total. Suppose time -saving can cut the requirement by 10 percent, that is, to 117 percent. The need would then be for 17 percent more engineers, instead of 30 percent. Which is to say that the problem would be 43 percent solved by a 10 percent saving in engineering time.

It appears that an information program aimed at expediting time-saving procedures could contribute toward achieving some very substantial results.

Increasing the Number. Some local agencies in California are providing engineering-aide and similar positions under programs which encourage young men to pursue engineering study and go on to become registered engineers. These programs are of course designed primarily to reduce immediate personnel shortages. But they also draw into engineering young men who would otherwise drift into other fields and are thus a long-term contribution to increasing the future number of highway engineers. There appear to be many cities and counties in which such programs could be adopted.

Arguments against such programs are that what the organizations really need are men with some experience and that when beginners who are soon to become engineers are hired they leave the organization upon becoming engineers. True as these arguments are, the advocates of education assistance programs seem to take a more realistic view of the prevailing situation. "Certainly we'd prefer men of experience," they say, "but they aren't here now and we can't wait. It is better to adjust ourselves to positions we can fill than to have a more ideal, but unfilled organization." As to men leaving the organization, they point out that others are leaving also, that those encouraged to educate themselves may in fact be less likely to leave and if they leave will be more favorably disposed toward the organization which helped them on so that some may be more likely to return in the future.

Characteristics of Local Problems

Cities and counties come in assorted shapes and sizes. In California, for example, there are 58 counties and more than 300 cities. Among the largest, three cities and three counties account for 30 percent of all local street and road work. The manpower problems of these large organizations are more like those of state highway departments than like those of small cities and counties. Among the smallest units, more than 250 cities account for only 15 percent of all local street and road work. Most of these have no engineers and hence no engineering manpower problems. This range of sizes is fairly typical of conditions nationwide (although the counties are especially large). Hence when we refer to "local manpower problems" we should probably focus attention on the middle group, the large group deserves separate treatment, and the small group can be dismissed.

A local agency, as it figures in the manpower problem discussed here, is thus a unit with annual street or road funds in the general range of $\$\frac{1}{4}$ million to $5 million and with a technical working force of from 2 or 3 to 50 individuals. Most agencies of this type attribute their difficulties in securing technical manpower to low salary ranges and limited opportunity for advancement.

These are undoubtedly prevailing problems and important factors in the manpower problem. But there are some significant exceptions. There are local units where salary ranges are not low. And there are local units offering low salaries and apparently limited opportunities that are not short of technical personnel. In other words, there is some evidence that shortcomings in salary and opportunity do not lead inevitably to personnel difficulties.

Information which may throw light on these problems is being obtained in the California survey. Reports of salary scales will be related to staff vacancies and where these do not correlate, attempt will be made to find out why. It is hoped that compensating factors may be found which may be generally applied by other cities and counties.

The preceding considerations apply if one thinks of single local units at single points in time. But when cities and counties are taken together and over the course of time, the premises are different. Salaries can be changed. Many cities and counties will grow. And in the general field of engineering in public administration there is plenty of opportunity. It is the view ahead as well as the immediate prospect that influences the young job applicant. Perhaps these considerations are already in the minds of some young engineers, accounting for the fact that local agencies are no worse off for technical manpower than they are. In many places such positive factors might well, as applicable in each case, be more effectively stated (or even just stated) in connection with recruitment activities. There is an almost fatalistic attitude toward the technical manpower problem in a good number of cities and counties. "Well, now why should a young engineer come to work here?" they ask. The response should probably be, "You're here. You tell me." Which might form the basis for a useful survey.

As local agencies are viewed collectively, a salary situation that is causing considerable loss of technical effort is found in many areas where several agencies are fairly close together. Most are in need of personnel and, as might be expected, few have exactly the same salary scales. The result is a continual movement of technical personnel from one agency to another. Often the move occurs about the time the individual has learned the procedure (and hence become of some use) in the place that he is leaving. Sometimes these moves are made for raises of as little as $25 a month.

An aggravated example of this situation is found in southern California, where the Los Angeles metropolitan area includes 16 sizeable cities, in addition to the City of Los Angeles, and the Los Angeles County Road Department. An association of city and county engineers in the area is considering the problem, and it will be of interest to see if a workable solution can be developed.

In Conclusion

The foregoing disucssion of some outstanding technical manpower problems at the local level, together with examples of corrective action already being taken in isolated cases, is by no means intended to minimize the seriousness of the problem or to suggest

that the examples cited hold prospect of complete solution. Quite the opposite. Data accumulated to date indicate that cities and counties are already seriously affected by technical manpower shortages. So far, most of them have been able to carry construction programs to the limit of available funds without delay. This appears to have been made possible by the presence of a nucleus of experienced personnel and by overtime work and other expedients. In other words, local engineering may be regarded as presently having an above-capacity output. There are many indications that the nucleus of experienced personnel is dwindling — thus the prospect of increased difficulties ahead and the importance of corrective action now. Some of this corrective action can be taken by individual cities and counties once they have the information on which to act effectively. Some of it will have to be taken on a collective basis. And this calls for immediate contribution by every agency with responsible interest in, and capabilities for, assisting in the solution of engineering manpower problems at the local level.

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