HIGHWAY RESEARCH BOARD
Bulletin 106

Manpower Needs in Highway Engineering

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HIGHWAY RESEARCH BOARD

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Manpower Needs in Highway Engineering

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Engineering-Personnel Needs for Highway Departments

M. EARL CAMPBELL, Highway Research Board, and
L. R. SCHUREMAN, Bureau of Public Roads

● THE shortage of technical personnel in this country has been a continuing problem in the administration of highway programs for the past several years. Even with the salary increases and other improvements in employment conditions which have been made, the state highway departments generally have not been able to improve appreciably their competitive positions in the technical-personnel market. This situation, while serious now, will be one of the major problems in instituting and carrying forward a highway construction program of the magnitude proposed by President Eisenhower's Advisory Committee on a National Highway Program.

Following discussions with the headquarters office of the American Association of State Highway Officials and other national agencies in the highway field, the Highway Research Board undertook (in the latter part of 1954) a canvass to determine the present shortage of highway engineers in the state highway departments and to obtain estimates of the number of highway engineers needed for an expanded program.

This paper is a report on the canvass and the use of the data obtained in estimating probable future engineer-personnel needs.

A questionnaire was prepared to collect the data desired. This form, shown in Figure 1, provides for reporting information for both the present program and expanded programs, broken down into several areas of activity. A statement of the purpose of the canvass and of the information desired, Figure 2, was distributed with the questionnaire. The forms were sent to the highway department of each state, the District of Columbia, Hawaii, and Puerto Rico.

Subsequently, to aid in arriving at complete estimates of the total number of engineers presently engaged in highway work in organizations with, or participating in, construction programs and possible future needs, the canvass was extended to cover cities with a population of 50,000 or more, toll-road authorities, and consulting firms.

ENGINEER-PERSONNEL SITUATION IN THE STATES

Data reported by the states, the District of Columbia, Hawaii, and Puerto Rico for their 1954 programs are shown in Tables 1, 2, and 3. The total number of engineers employed in these highway departments as shown in Table 1 is 18,034. The average distribution among areas of activity is about 6 percent in planning and traffic; 5 percent in location; 23 percent in road design; 8 percent in bridge design; 40 percent in construction; 7 percent in materials and testing; 6 percent in maintenance; and 5 percent in "other," which includes administration, contracts, estimates, right-of-way and, in some cases, trainees.

Table 2 shows that about two thirds of the highway departments are using consultants to some extent and that it would be necessary to employ 4,192 additional engineers in these highway departments if consultants were not used. It is interesting to note that this number is about 20 percent of the number of engineers on the rolls of the highway departments. The distribution of the 4,192 engineers among the several areas of activity is 3 percent in planning and traffic, 3 percent in location, 68 percent in road design, 18 percent in bridge design, 5 percent in construction, and 3 percent divided between materials and testing and "other."

Table 3 shows the numbers of engineers the highway departments desire in addition to those shown in Tables 1 and 2 in order to work at maximum effectiveness. The total, termed in this report the "present shortage," is 3,990. Its percentage distribution among the several areas of activity is quite close to the percentage distribution of engineers on the rolls as given above. Five states (Colorado, New Hampshire, Rhode Island, Utah

STATE _____ DATE _____

STATEMENT OF PURPOSE

The Highway Research Board is canvassing each state for a determination of the present shortage of professional engineers. It is also desirable to anticipate the requirements in engineering personnel if the proposed additional fifty billion dollar-10 year program of the Federal Government is realized. The information obtained will be published by the Board. If there should be restrictions on publication of the information in whole or in part, or by name of state, please indicate.

INFORMATION REQUESTED

Explanation of Items

Item 1

This question relates to engineers of professional grade, that is, registered professional engineers, or those qualified to register.

Item 2

The intent is to determine the number of engineering positions it would be necessary to create in order to handle the work now being handled by firms of consulting engineers.

Item 3

It may be deemed desirable to supplement the number of professional engineers now engaged (listed in Items 1 and 2) in order to do work at the highest level of effectiveness. This question seeks to determine the additional number.

Item 4

If the proposed 50 billion dollar-ten year program becomes a reality it appears that the capital improvement program may be about doubled. It is believed that the expenditures will probably be devoted to capital improvements (construction, reconstruction, additions and betterments), but the addition of these capital improvements will no doubt result in increases in expenditures by all the Bureaus.

Item 5

If engineers were in sufficient supply, how many would be employed to handle the program?

Item 6

Even though engineers were available it might still be expedient to employ consultants on certain special jobs, such as expressway design. An estimate of the number is desired.

Item 7

In many state highway departments retirements during the next ten years will be specially high due to the large percentage of engineers who have served for 25 years or more with the department. Some of these may go to work for consultants but it is likely that the larger number will not continue in highway engineering work.

Figure 1.

and Washington) reported no shortage. At the other extreme, three states are operating with less than 50 percent of the number of engineers desired. The totals for each area of activity show that the shortage in planning and traffic is 27 percent of the number on the rolls; in location, 11 percent; road design, 26 percent; bridge design, 27 percent; construction, 22 percent; materials and testing,

PROFESSIONAL ENGINEER STATUS

STATE _____ DATE _____

PRESENT PROGRAM

Highway Bureau or Function	(1) No. of Professional Engineers Employed in 1954	(2) No of Engineering Positions Affected by Consultants	(3) No. of Professional Engineers Desired In Addition to (1) and (2)
Planning & Traffic			
Location			
Road Design			
Bridge Design			
Construction			
Materials & Testing			
Maintenance			
Other			
TOTAL			

EXPANDED PROGRAM

Highway Bureau or Function	(4) Minimum Professional Engineers Required for Program Expanded by		(5) Optimum Professional Engineers Desired for Program Expanded by		(6) No. of Positions Expected to be Filled by Consultants for Program Expanded by		(7) No. of Positions to be Vacated by Retirement During Next 10 Years
	50%	100%	50%	100%	50%	100%	
Planning & Traffic							
Location							
Road Design							
Bridge Design							
Construction							
Materials & Testing							
Maintenance							
Other							
TOTAL							

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Figure 2.

21 percent; maintenance, 15 percent; and "other," 17 percent. The overall shortage is 22 percent of the number on the rolls.

The sum of the 18,034 engineers on the rolls, the 4,192 equivalent to work handled by consultants, and the 3,990 additional engineers desired is 26,216. This is the total number desired for the 1954 programs of the highway departments involving in total a capital outlay of about $2½ billion.

TABLE 1

NUMBER OF PROFESSIONAL ENGINEERS EMPLOYED IN 1954

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama	9	11	37	23	181	67	60	15	403
Arizona	2	5	7	9	23	5	0	8	59
Arkansas	2	4	5	16	22	5	11	4	69
California	287	315	968	207	1154	217	109	131	3388
Colorado	10	2	20	10	70	20	8	7	147
Connecticut	11	20	28	19	31	3	24	27	163
Delaware	6	-	8	5	25	5	8	10	67
Florida	7	-	13	5	75	3	31	3	137
Georgia	14	19	22	16	200	24	16	18	329
Idaho	4	7	4	5	24	6	2	11	63
Illinois	123	*	338	58	391	109	96	16	1131
Indiana	16	8	43	46	154	19	19	11	316
Iowa	13	13	19	30	183	48	30	24	360
Kansas	22	5	40	18	168	48	5	32	338
Kentucky	17	*	62	24	105	10	26	8	252
Louisiana	12	**	27	19	174	15	**	29	276
Maine	1	2	12	8	40	2	1	2	68
Maryland	6	10	25	17	47	10	5	45	165
Massachusetts	97	125	155	41	208	15	69	32	742
Michigan	40	*	175	80	50	40	17	5	407
Minnesota	14	3	49	13	105	18	20	25	247
Mississippi	9	***	4	7	69	8	11	3	111
Missouri	10	30	129	27	183	52	26	13	470
Montana	1	5	7	8	39	6	10	9	85
Nebraska	19	3	43	20	114	18	20	8	245
Nevada	4	6	20	6	14	8	9	9	76
New Hampshire	6	1	31	6	47	4	46	59	200
New Jersey	40	*	269	32	135	-	3	-	479
New Mexico	2	4	5	3	43	3	6	7	73
New York	37	*	494	139	968	85	65	51	1839
North Carolina	5	33	42	33	150	21	-	-	284
North Dakota	4	2	6	6	23	4	7	9	61
Ohio	31	*	210	49	264	62	28	10	654
Oklahoma	1	8	21	11	36	8	22	8	115
Oregon	28	40	26	21	233	20	26	58	452
Pennsylvania	15	15	100	20	60	15	15	60	300
Rhode Island	3	3	7	4	19	3	2	2	43
South Carolina	13	8	22	14	113	9	51	-	230
South Dakota	2	1	13	12	31	8	4	8	79
Tennessee	40	100	45	17	240	47	31	40	560
Texas	42	103	195	157	310	42	26	-	875
Utah	4	6	17	6	35	4	6	-	78
Vermont	8	10	12	15	62	4	25	17	153
Virginia	24	47	33	17	110	21	56	68	376
Washington	17	19	17	24	82	13	12	22	206
West Virginia	4	2	8	7	26	2	24	3	76
Wisconsin	23	30	145	17	145	9	34	19	422
Wyoming	1	***	5	4	53	4	7	-	74
Dist. of Columbia	12	-	6	8	17	3	2	-	48
Hawaii	2	-	12	5	36	3	-	1	59
Puerto Rico	22	-	62	14	60	3	20	3	184
Totals	1142	1025	4063	1378	7147	1178	1151	950	18034

* Location and Road Design combined
** Location, Construction and Maintenance combined
***Location and Construction combined

TABLE 2

NUMBER OF ENGINEERING POSITIONS AFFECTED BY CONSULTANTS

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama	-	-	-	-	-	-	-	-	-
Arizona	0	0	0	0	0	0	0	0	0
Arkansas	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0
Colorado	-	-	-	-	-	-	-	-	-
Connecticut	-	25	75	40	15	-	-	50	205
Delaware	3	-	4	10	-	-	-	-	17
Florida	0	-	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0
Idaho	1	2	3	4	-	-	-	-	10
Illinois	10	*	25	25	-	-	-	-	60
Indiana	-	-	70	48	-	-	-	-	118
Iowa	0	0	2	10	0	0	0	1	13
Kansas	0	0	15	18	0	6	0	24	63
Kentucky	1	*	18	8	-	-	-	-	27
Louisiana	0	**	15	39	7	1	**	16	78
Maine	-	-	2	2	3	1	-	-	8
Maryland	0	10	25	30	16	0	0	4	85
Massachusetts	-	46	320	***	-	-	-	-	366
Michigan	0	*	15	50	0	1	0	0	66
Minnesota	0	0	0	2	0	0	0	0	2
Mississippi	1	1	0	0	1	0	0	0	3
Missouri	0	14	15	15	0	9	0	0	53
Montana	-	-	-	-	1	-	-	3	4
Nebraska	-	-	22	5	4	2	-	-	33
Nevada	0	0	0	0	0	0	0	0	0
New Hampshire	-	-	-	-	-	-	-	-	-
New Jersey	-	*	25	25	-	-	-	-	50
New Mexico	0	0	2	0	0	0	0	0	2
New York	50	*	2000	300	150	-	-	-	2500
North Carolina	0	0	0	0	0	0	0	0	0
North Dakota	0	1	2	0	2	0	0	0	5
Ohio	-	*	100	20	25	-	-	-	145
Oklahoma	0	1	1	1	1	0	0	0	4
Oregon	0	0	0	0	0	0	0	0	0
Pennsylvania	5	5	40	40	-	-	-	-	90
Rhode Island	5	3	8	8	4	2	0	4	34
South Carolina	0	0	0	8	0	0	0	0	8
South Dakota	0	3	3	0	0	0	0	0	6
Tennessee	-	-	-	5	-	-	-	-	5
Texas	0	0	0	0	0	0	0	0	0
Utah	0	0	0	0	0	0	0	0	0
Vermont	1	1	20	2	-	-	-	-	24
Virginia	6	0	12	6	0	5	0	0	29
Washington	0	0	0	0	0	0	0	0	0
West Virginia	2	-	-	10	-	-	-	-	12
Wisconsin	-	-	10	-	-	-	-	-	10
Wyoming	0	0	0	0	0	0	0	0	0
Dist. of Columbia	25	-	6	16	-	-	-	-	47
Hawaii	0	0	0	0	0	0	0	0	0
Puerto Rico	-	-	5	5	-	-	-	-	10
Totals	110	112	2860	752	229	27	0	102	4192

* Location and Road Design combined.
** Location, Construction and Maintenance combined.
*** Location and Construction combined.

TABLE 3

NUMBER OF PROFESSIONAL ENGINEERS DESIRED IN ADDITION TO (1) AND (2)

State	Plan. & Traff	Loc	Road Design	Bridge Design	Const.	Mat & Test'g.	Maint.	Other	Total
Alabama	6	5	15	10	36	15	5	5	97
Arizona	1	0	1	2	0	1	0	0	5
Arkansas	3	3	2	5	15	2	-	4	34
California	20	0	100	20	60	10	0	0	210
Colorado	-	-	-	-	-	-	-	-	-
Connecticut	3	3	10	10	170	0	2	2	200
Delaware	-	7	4	5	6	2	-	2	26
Florida	3	-	35	5	25	3	10	6	87
Georgia	7	11	11	5	19	7	5	2	67
Idaho	3	7	6	4	36	4	7	2	69
Illinois	26	*	95	8	96	23	20	4	272
Indiana	17	14	17	11	89	17	-	-	165
Iowa	3	0	3	0	23	7	1	0	37
Kansas	6	5	5	6	39	10	0	6	77
Kentucky	0	*	6	0	12	0	2	0	20
Louisiana	6	**	10	10	34	2	**	13	75
Maine	2	-	5	2	15	-	-	-	24
Maryland	0	0	10	5	7	0	1	2	25
Massachusetts	30	-	-	-	40	22	25	39	156
Michigan	12	*	10	15	10	15	2	0	64
Minnesota	6	1	8	15	14	5	0	7	56
Mississippi	1	***	1	4	12	1	1	0	20
Missouri	1	6	31	5	40	2	0	0	85
Montana	0	0	0	2	10	2	1	1	16
Nebraska	5	3	5	5	16	10	4	2	50
Nevada	0	2	4	0	4	1	0	2	13
New Hampshire	-	-	-	-	-	-	-	-	-
New Jersey	10	*	50	25	40	-	4	-	129
New Mexico	2	2	5	3	5	0	0	0	17
New York	50	*	400	30	200	-	20	-	700
North Carolina	2	5	10	8	100	20	-	-	145
North Dakota	2	2	4	2	2	2	3	1	18
Ohio	20	*	50	10	100	20	15	10	225
Oklahoma	5	10	15	10	25	8	0	10	83
Oregon	2	4	2	5	5	2	2	3	25
Pennsylvania	2	3	10	10	10	5	-	-	40
Rhode Island	-	-	-	-	-	-	-	-	-
South Carolina	3	8	8	8	31	4	14	-	76
South Dakota	3	3	10	10	5	6	2	5	44
Tennessee	0	0	0	5	0	0	0	0	5
Texas	0	0	40	40	45	0	0	0	125
Utah	0	0	0	0	0	0	0	0	0
Vermont	1	2	3	2	7	-	-	3	18
Virginia	3	3	3	3	26	0	4	20	62
Washington	0	0	0	0	0	0	0	0	0
West Virginia	3	2	6	10	20	1	2	2	46
Wisconsin	6	0	9	5	14	1	4	1	40
Wyoming	4	***	5	6	26	2	3	1	46
Dist. of Columbia	11	-	4	2	17	1	2	-	37
Hawaii	2	-	3	2	6	0	4	0	17
Puerto Rico	6	-	21	5	25	5	4	2	68
Totals	299	111	1057	359	1590	242	176	156	3990

* Location and Road Design combined.
** Location, Construction and Maintenance combined.
*** Location and Construction combined.

TABLE 4

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 50%

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama	22	23	77	50	220	85	80	20	577
Arizona	2	7	10	12	30	7	0	10	78
Arkansas	4	7	8	20	35	6	14	9	103
California	316	347	1162	246	1329	249	110	136	3895
Colorado	12	2	25	12	80	30	8	7	176
Connecticut	20	65	50	45	310	5	25	30	550
Delaware	15	11	12	15	37	9	-	13	112
Florida	15	-	40	15	125	6	59	12	272
Georgia	17	24	33	30	300	40	18	27	489
Idaho	6	10	6	20	32	7	2	13	96
Illinois	150	*	450	90	525	145	120	20	1500
Indiana	62	44	148	143	418	66	21	13	915
Iowa	20	18	34	56	258	69	31	33	519
Kansas	31	12	90	63	260	60	5	40	561
Kentucky	13	*	102	45	150	10	30	9	359
Louisiana	6	**	60	45	267	25	**	49	452
Maine	3	2	25	15	75	3	1	2	126
Maryland	8	24	75	65	110	12	6	60	360
Massachusetts	150	250	480	130	360	50	100	80	1600
Michigan	50	*	235	120	75	60	20	5	585
Minnesota	21	6	73	40	159	31	21	36	387
Mississippi	13	***	6	15	95	11	12	3	155
Missouri	13	60	195	62	300	65	30	13	738
Montana	1	8	10	13	70	8	12	12	134
Nebraska	36	9	100	45	201	45	28	15	479
Nevada	5	9	30	9	21	12	11	12	109
New Hampshire	6	1	31	6	47	4	46	59	200
New Jersey	75	*	300	75	150	10	7	-	617
New Mexico	3	6	8	6	50	4	6	7	90
New York	80	*	850	240	1310	80	55	55	2670
North Carolina	5	43	55	50	225	30	-	-	408
North Dakota	9	6	10	10	34	7	15	12	103
Ohio	64	*	460	110	580	110	50	25	1399
Oklahoma	1	12	28	15	52	10	24	8	150
Oregon	31	53	34	37	290	25	30	70	570
Pennsylvania	25	25	165	80	80	35	15	60	485
Rhode Island	10	9	23	18	29	7	3	8	107
South Carolina	18	24	30	19	154	14	85	-	344
South Dakota	6	10	40	33	42	20	10	15	176
Tennessee	40	100	45	22	240	47	31	40	565
Texas	52	129	244	196	388	52	32	-	1093
Utah	4	7	22	8	45	5	6	-	97
Vermont	13	18	39	23	102	7	0	27	229
Virginia	42	61	64	30	156	30	60	88	531
Washington	19	21	19	27	90	14	13	24	227
West Virginia	7	3	12	12	34	3	26	5	102
Wisconsin	27	30	185	20	185	10	34	19	510
Wyoming	5	***	15	15	120	6	10	5	176
Dist of Columbia	40	-	30	45	25	4	2	-	146
Hawaii	4	-	20	8	60	6	4	1	103
Puerto Rico	35	-	105	30	103	6	31	6	316
Totals	1632	1496	6370	2556	10433	1662	1359	1213	26721

* Location and Road Design combined
** Location, Construction and Maintenance combined.
*** Location and Construction combined

TABLE 5

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 100%

State	Plan.& Traff.	Loc.	Road Design	Bridge Design	Const.	Mat & Test'g.	Maint.	Other	Total
Alabama	30	31	104	66	300	100	90	25	746
Arizona	3	9	12	15	38	9	0	13	99
Arkansas	8	7	12	30	50	8	16	9	140
California	345	380	1355	285	1505	280	110	140	4400
Colorado	14	4	30	15	90	40	8	10	211
Connecticut	25	75	55	50	350	7	30	35	627
Delaware	20	14	16	20	50	14	-	15	149
Florida	20	-	60	25	175	8	66	18	372
Georgia	19	33	54	40	393	58	24	34	655
Idaho	9	13	7	25	36	8	2	15	115
Illinois	170	*	510	110	600	160	140	25	1715
Indiana	76	54	192	187	526	82	24	14	1155
Iowa	24	22	44	72	309	82	31	40	624
Kansas	31	14	120	84	340	70	5	52	716
Kentucky	14	*	121	60	175	10	32	10	422
Louisiana	9	**	75	60	319	31	**	58	552
Maine	4	3	35	20	90	5	1	4	162
Maryland	10	32	95	85	145	15	6	75	463
Massachusetts	170	430	640	170	480	60	120	100	2170
Michigan	60	*	290	160	100	70	22	5	707
Minnesota	24	7	89	50	200	39	21	43	473
Mississippi	15	***	8	18	105	12	12	3	173
Missouri	13	80	295	78	390	70	32	13	971
Montana	2	10	12	15	100	9	12	14	174
Nebraska	40	12	140	60	268	60	28	20	628
Nevada	6	12	40	12	28	16	14	16	144
New Hampshire	6	1	31	6	47	4	46	59	200
New Jersey	100	*	350	120	200	20	10	-	800
New Mexico	4	8	10	8	60	6	8	8	112
New York	85	*	900	255	1390	85	55	55	2825
North Carolina	7	53	65	60	300	35	-	-	520
North Dakota	12	8	12	15	40	10	20	14	131
Ohio	75	*	600	150	750	140	55	30	1800
Oklahoma	1	15	36	19	68	12	32	10	193
Oregon	33	65	40	40	315	30	34	73	630
Pennsylvania	30	30	185	100	90	40	15	60	550
Rhode Island	12	12	30	24	35	9	4	10	136
South Carolina	25	32	40	25	208	20	110	0	460
South Dakota	8	13	50	42	50	26	13	18	220
Tennessee	40	100	56	30	240	47	31	40	584
Texas	57	139	263	212	418	57	35	-	1181
Utah	5	9	30	10	60	7	6	-	127
Vermont	16	23	43	27	135	10	0	32	286
Virginia	52	70	76	34	196	36	60	88	612
Washington	25	28	25	36	123	19	18	33	307
West Virginia	10	4	16	14	40	3	26	6	119
Wisconsin	27	30	215	20	215	11	34	19	571
Wyoming	8	***	20	20	160	8	15	8	239
Dist. of Columbia	50	-	45	65	35	5	3	-	203
Hawaii	6	-	30	12	90	10	8	3	159
Puerto Rico	40	-	118	34	116	8	35	7	358
Totals	1895	1882	7697	3190	12543	1981	1519	1379	32086

* Location and Road Design combined.
** Location, Construction and Maintenance combined
*** Location and Construction combined.

TABLE 6

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 50%

State	Plan. & Traff.	Loc.	Road Design	Bridge Design	Const.	Mat & Test'g	Maint.	Other	Total
Alabama[1]	22	23	77	50	220	85	80	20	577
Arizona[2]	2	7	12	14	33	7	0	10	85
Arkansas	6	8	10	28	45	10	14	10	131
California	336	347	1281	271	1394	261	110	136	4136
Colorado	15	3	30	15	90	40	10	8	211
Connecticut	25	70	65	60	340	5	30	30	625
Delaware	15	15	16	20	45	10	-	15	136
Florida	18	0	50	15	150	8	65	15	321
Georgia	27	29	52	35	350	61	24	30	608
Idaho	5	12	7	22	36	8	2	13	105
Illinois	200	*	610	120	650	175	155	25	1935
Indiana	67	47	163	158	454	71	23	14	997
Iowa	22	19	36	60	285	76	31	35	564
Kansas	33	12	95	70	290	65	5	45	615
Kentucky	17	*	108	48	160	10	32	11	386
Louisiana	8	**	60	50	277	28	**	50	473
Maine	4	3	35	20	85	4	2	4	157
Maryland	9	30	80	75	125	15	6	60	400
Massachusetts	165	275	528	143	396	55	110	88	1760
Michigan	65	*	250	130	110	70	23	5	653
Minnesota	26	6	84	50	171	39	21	42	439
Mississippi	16	***	10	16	100	13	16	3	174
Missouri	14	75	260	70	370	70	34	13	906
Montana	2	10	12	14	80	10	13	14	155
Nebraska	40	10	110	55	211	50	30	10	516
Nevada[1]	5	9	30	9	21	12	11	12	109
New Hampshire	6	1	31	6	47	4	46	59	200
New Jersey	100	*	350	125	200	15	8	0	798
New Mexico	3	6	8	6	50	4	6	7	90
New York	90	*	1055	270	1525	90	55	55	3140
North Carolina	10	53	55	5	225	40	0	0	388
North Dakota	9	8	15	12	38	9	18	12	121
Ohio	70	*	525	120	620	120	55	30	1540
Oklahoma	2	14	40	17	60	14	31	12	190
Oregon	32	56	38	40	300	28	33	73	600
Pennsylvania	25	25	170	85	85	40	15	60	505
Rhode Island[1]	10	9	23	18	29	7	3	8	107
South Carolina	20	30	40	25	176	18	100	0	409
South Dakota	8	13	50	42	50	26	13	18	220
Tennessee	40	100	45	17	240	47	31	40	580
Texas	52	129	294	246	444	52	32	0	1249
Utah	5	9	30	10	50	6	6	0	116
Vermont	14	20	40	24	117	8	0	29	252
Virginia	45	65	68	33	166	30	60	88	555
Washington	21	23	21	30	99	15	14	26	249
West Virginia	10	4	16	14	40	4	26	6	120
Wisconsin[1]	27	30	185	20	185	10	34	19	510
Wyoming[1]	5	***	15	15	120	6	10	5	176
Dist. of Columbia	45	0	35	50	30	5	2	0	167
Hawaii	6	-	30	10	70	8	6	3	133
Puerto Rico	40	-	120	35	120	9	36	8	368
Totals	1859	1605	7370	2893	11574	1873	1487	1276	29937

[1] Not reported. Figure shown same as in Table 4.
[2] Only total reported. Breakdown estimated.
* Location and Road Design combined.
** Location, Construction and Maintenance combined.
*** Location and Construction combined.

TABLE 7

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 100%

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama[1]	30	31	104	66	300	100	90	25	746
Arizona[2]	3	9	13	16	41	9	0	14	105
Arkansas	10	16	14	40	65	15	16	10	186
California	365	380	1495	315	1575	295	110	140	4675
Colorado	18	6	40	18	100	50	12	12	256
Connecticut	30	80	75	70	385	7	35	35	717
Delaware	20	18	20	25	60	15	-	17	175
Florida	25	-	75	25	200	10	77	20	432
Georgia	27	36	104	45	470	93	30	38	843
Idaho	8	15	8	28	42	9	2	15	127
Illinois	260	*	690	140	730	200	175	30	2225
Indiana	83	58	211	207	575	89	27	16	1266
Iowa	28	24	48	80	365	97	31	44	717
Kansas	33	14	126	93	400	75	5	60	806
Kentucky	18	*	130	64	190	10	36	12	460
Louisiana	10	**	75	75	334	35	**	59	588
Maine	5	4	45	25	105	6	2	6	198
Maryland	12	40	100	95	160	20	6	75	508
Massachusetts	187	473	704	187	528	66	132	110	2387
Michigan	90	*	315	180	135	80	25	5	830
Minnesota	29	7	111	60	225	45	21	51	549
Mississippi	17	***	12	20	110	14	16	3	192
Missouri	14	125	350	94	445	78	38	13	1157
Montana	2	14	30	16	120	12	14	16	224
Nebraska	50	14	150	70	278	65	30	10	667
Nevada[1]	6	12	40	12	28	16	14	16	144
New Hampshire	6	1	31	6	47	4	46	59	200
New Jersey	125	*	400	175	250	30	12	-	992
New Mexico	4	8	10	8	60	6	8	10	114
New York	100	*	1100	290	1690	110	55	55	3400
North Carolina	15	73	65	10	300	45	-	-	508
North Dakota	12	10	20	16	50	12	24	14	158
Ohio	80	*	675	170	840	160	65	35	2025
Oklahoma	2	18	48	23	80	17	38	14	240
Oregon	34	68	42	42	330	31	35	74	656
Pennsylvania	35	35	200	120	100	50	15	60	615
Rhode Island[1]	12	12	30	24	35	9	4	10	136
South Carolina	30	40	50	35	252	25	130	0	562
South Dakota	10	16	60	52	65	30	16	20	269
Tennessee	40	100	56	30	240	47	31	40	584
Texas	57	139	317	266	479	57	35	-	1350
Utah	6	11	40	12	65	8	6	-	148
Vermont	18	26	45	29	166	12	0	38	334
Virginia	60	75	83	38	206	36	60	88	646
Washington	28	31	28	40	135	21	20	36	339
West Virginia	12	6	20	20	50	4	30	7	149
Wisconsin[1]	27	30	215	20	215	11	34	19	571
Wyoming[1]	8	***	20	20	160	8	15	8	239
Dist of Columbia	55	-	50	70	40	6	4	-	225
Hawaii	8	-	40	14	120	12	10	6	210
Puerto Rico	44	-	130	38	125	12	40	9	398
Totals	2208	2075	8860	3634	14066	2274	1677	1454	36248

[1] Not reported Figures shown same as in Table 5

[2] Only total reported Breakdown estimated

* Location and Road Design combined

** Location, Construction and Maintenance combined

*** Location and Construction combined

TABLE 8

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 50%

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama	0	0	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0	0	0
Arkansas	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0
Colorado	-	-	-	-	-	-	-	-	-
Connecticut	-	-	100	40	-	-	-	-	140
Delaware	-	-	4	15	-	-	-	-	19
Florida	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0
Idaho	1	3	4	12	-	-	-	-	20
Illinois	12	*	33	39	-	-	-	-	84
Indiana	0	0	0	0	0	0	0	0	0
Iowa	0	0	0	0	0	0	0	0	0
Kansas	0	0	0	0	0	8	0	8	16
Kentucky	3	*	24	2	-	-	-	-	29
Louisiana	0	0	0	0	-	0	0	0	0
Maine	-	-	3	5	5	-	-	-	13
Maryland	2	20	55	58	78	5	0	15	233
Massachusetts	-	75	410	**	-	-	-	-	485
Michigan	0	*	10	75	0	1	0	0	86
Minnesota	0	0	0	2	0	0	0	0	2
Mississippi	0	0	0	0	0	0	0	0	0
Missouri	0	0	0	10	0	4	0	0	14
Montana	1	-	-	-	5	-	-	5	11
Nebraska	-	-	33	10	6	3	-	-	52
Nevada	-	-	-	-	-	-	-	-	-
New Hampshire	-	-	-	-	-	-	-	-	-
New Jersey	-	*	25	40	-	-	-	-	65
New Mexico	0	0	2	0	0	0	0	0	2
New York	-	*	1000	100	-	-	-	-	1100
North Carolina	0	0	0	0	0	0	0	0	0
North Dakota	0	1	2	0	4	0	0	0	7
Ohio	-	-	-	-	-	-	-	-	-
Oklahoma	0	10	20	10	0	0	0	0	40
Oregon	0	0	0	0	0	0	0	0	0
Pennsylvania	-	-	40	60	-	-	-	-	100
Rhode Island	7	5	12	12	10	6	-	4	56
South Carolina	0	0	0	0	0	0	0	0	0
South Dakota	0	10	10	0	0	0	0	0	20
Tennessee	-	-	-	-	-	-	-	-	-
Texas	-	-	-	-	-	-	-	-	-
Utah	-	-	-	-	-	-	-	-	-
Vermont	-	6	5	5	-	-	-	-	16
Virginia	10	0	0	5	0	5	0	0	20
Washington	0	0	0	0	0	0	0	0	0
West Virginia	4	-	-	10	-	-	-	-	14
Wisconsin	-	-	20	5	20	-	-	-	45
Wyoming	0	0	0	0	0	0	0	0	0
Dist of Columbia	20	-	20	35	0	0	0	0	75
Hawaii	0	-	10	3	0	0	0	0	13
Puerto Rico	-	-	8	5	-	-	-	-	13
Totals	60	130	1850	558	128	32	0	32	2790

* Location and Road Design combined

** Road Design and Bridge Design combined

TABLE 9

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 100%

State	Plan. & Traff.	Loc.	Road Design	Bridge Design	Const.	Mat. & Test'g.	Maint.	Other	Total
Alabama	0	0	0	0	0	0	0	0	0
Arizona	0	0	0	0	0	0	0	0	0
Arkansas	0	0	0	0	0	0	0	0	0
California	0	0	0	0	0	0	0	0	0
Colorado	-	-	-	-	-	-	-	-	-
Connecticut	-	-	125	45	-	-	-	-	170
Delaware	-	-	8	20	-	-	-	-	28
Florida	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0
Idaho	1	4	5	16	-	-	-	-	26
Illinois	14	*	38	48	-	-	-	-	100
Indiana	0	0	0	0	0	0	0	0	0
Iowa	0	0	0	0	0	0	0	0	0
Kansas	0	0	0	0	0	10	0	12	22
Kentucky	4	*	33	3	-	-	-	-	40
Louisiana	0	0	0	0	-	0	0	0	0
Maine	-	-	5	10	10	-	-	-	25
Maryland	3	30	75	78	113	10	0	30	339
Massachusetts	-	100	610	**	-	-	-	-	710
Michigan	0	*	15	100	0	1	0	0	116
Minnesota	0	0	0	2	0	0	0	0	2
Mississippi	0	0	0	0	0	0	0	0	0
Missouri	0	0	0	20	0	8	0	0	28
Montana	1	-	-	-	10	-	-	10	21
Nebraska	-	-	44	20	8	4	-	-	76
Nevada	-	-	-	-	-	-	-	-	-
New Hampshire	-	-	-	-	-	-	-	-	-
New Jersey	-	*	50	80	-	-	-	-	130
New Mexico	0	0	3	0	0	0	0	0	3
New York	-	*	1300	200	-	-	-	-	1500
North Carolina	0	0	0	0	0	0	0	0	0
North Dakota	0	2	4	0	6	0	0	0	12
Ohio	-	-	-	-	-	-	-	-	-
Oklahoma	0	20	30	20	0	0	0	0	70
Oregon	0	0	0	0	0	0	0	0	0
Pennsylvania	-	-	50	70	-	-	-	-	120
Rhode Island	7	8	18	24	15	9	-	4	85
South Carolina	0	0	0	0	0	0	0	0	0
South Dakota	0	15	15	0	0	0	0	0	30
Tennessee	-	-	-	-	-	-	-	-	-
Texas	-	-	-	-	-	-	-	-	-
Utah	-	-	-	-	-	-	-	-	-
Vermont	-	12	10	10	-	-	-	-	32
Virginia	20	0	0	10	0	7	0	0	37
Washington	0	0	0	0	0	0	0	0	0
West Virginia	4	-	-	10	-	-	-	-	14
Wisconsin	-	-	35	10	35	-	-	-	80
Wyoming	0	0	0	0	0	0	0	0	0
Dist. of Columbia	25	-	30	40	0	0	0	0	95
Hawaii	0	-	15	6	0	0	0	0	21
Puerto Rico	-	-	12	8	-	-	-	-	20
Totals	79	191	2530	850	197	49	0	56	3952

* Location and Road Design combined.
** Location, Construction and Maintenance combined.
*** Location and Construction combined.

TABLE 10

NUMBER OF POSITIONS TO BE VACATED BY RETIREMENT DURING NEXT 10 YEARS

State	Plan & Traff	Loc	Road Design	Bridge Design	Const	Mat & Test'g	Maint	Other	Total
Alabama	1	5	1	5	25	10	20	3	70
Arizona	-	1	1	-	3	1	-	4	10
Arkansas	2	2	4	5	25	2	3	1	44
California	----------		No breakdown						160
Colorado	6	2	20	10	60	20	3	4	125
Connecticut	4	6	10	7	10	1	7	15	60
Delaware	2	-	2	2	8	1	3	4	22
Florida	4	-	10	4	40	2	25	4	89
Georgia	1	3	10	4	23	9	9	5	64
Idaho	2	2	4	2	10	1	-	5	26
Illinois	----------		No breakdown						368
Indiana	2	-	5	6	12	1	1	2	29
Iowa	2	0	1	3	23	9	13	3	54
Kansas	1	0	4	0	10	6	2	17	40
Kentucky	6	*	9	2	10	5	6	3	41
Louisiana	1	**	2	5	26	3	*	8	45
Maine	-	-	-	1	9	-	-	-	10
Maryland	1	2	6	6	15	1	2	15	48
Massachusetts	----------		No estimate						--
Michigan	8	*	35	12	10	5	12	0	82
Minnesota	6	0	10	2	16	0	9	7	50
Mississippi	3	***	1	0	12	2	3	2	23
Missouri	5	6	30	9	46	10	10	8	124
Montana	-	3	-	2	10	-	1	5	21
Nebraska	1	1	15	4	8	3	12	5	47
Nevada	0	2	1	1	3	2	6	2	17
New Hampshire	0	0	3	2	0	1	6	1	13
New Jersey	10	*	50	18	15	7	3	-	103
New Mexico	1	2	2	2	10	2	2	3	24
New York	10	*	100	50	300	10	20	10	500
North Carolina	1	7	5	5	25	1	-	-	44
North Dakota	2	2	1	2	1	1	2	4	15
Ohio	10	*	39	15	40	25	18	10	157
Oklahoma	0	1	2	1	4	1	2	1	12
Oregon	0	3	3	2	16	0	3	13	40
Pennsylvania	10	5	65	15	40	10	10	45	200
Rhode Island	1	2	5	2	9	1	1	1	22
South Carolina	0	2	1	2	24	2	20	0	51
South Dakota	0	0	5	3	5	2	2	2	19
Tennessee	----------		No estimate						--
Texas	----------		No breakdown						86
Utah	0	1	2	5	5	1	2	0	16
Vermont	1	1	1	6	10	1	3	6	29
Virginia	0	1	1	0	10	0	5	3	20
Washington	1	2	3	1	13	1	2	8	31
West Virginia	1	2	4	2	8	1	10	2	30
Wisconsin	----------		No breakdown						65
Wyoming	----------		No breakdown						25
Dist of Columbia	4	-	2	2	15	7	2	-	32
Hawaii	1	-	2	1	6	1	0	1	12
Puerto Rico	-	-	1	-	2	-	4	-	7
Total									3222

* Location and Road Design combined.
** Road Design and Bridge Design combined.

1954 ENGINEERING-PERSONNEL SITUATION IN THE CITIES

Completed questionnaires were returned by 141 of the 205 cities covered in the canvass. For purpose of analysis, the cities were divided into four groups: Group I from 50,000 to 75,000 population; Group II from 75,000 to 100,000 population; Group III from 100,000 to 500,000 population; and Group IV above 500,000 population. The data reported are shown in Tables 11 through 50.

The total number of engineers on the rolls in 1954 in the 141 reporting cities is 2,019. The average distribution among areas of activity is about 16 percent in planning and traffic, 28 percent in street design, 11 percent in bridge design, 28 percent in construction, 4 percent in materials and testing, 6 percent in maintenance and 7 percent in other categories with only minor variations among the four groups.

About 65 percent of the cities used consultants in 1954, again with only minor variations among the groups. The reports show that it would be necessary to employ 542 additional engineers, about 27 percent increase over those now on the rolls, if consultants were not used. The average distribution of the 542 engineers equivalent to work done by consultants is 13 percent in planning and traffic, 25 percent in street design, 36 percent in bridge design, 9 percent in construction, 8 percent in materials and testing, 1 percent in maintenance, and 8 percent in other. There is considerable variation among the four population groups in this percentage distribution, the greatest variation occurring in bridge design with 15 percent for Group I and 56 percent for Group IV, and in construction with 12 percent for Group I and 3 percent for Group IV.

The present shortage in the 141 reporting cities totals 845 engineers. The percentage distribution of the total shortage among the several areas of activity is quite close to the distribution of engineers on the rolls in 1954. Twenty-seven of the 141 cities reported no shortage. The shortage in Group I is 76 percent of the number on the rolls; in Group II, 63 percent; in Group III, 43 percent; and in Group IV, 33 percent. The overall shortage is 42 percent of the number on the rolls. There are extreme variations in the percent shortage in the several areas of activity in the four groups.

The sum of the 2,019 engineers on the rolls, the 542 equivalent to work handled by consultants and the 845 additional engineers desired is 3,406. This is the total number of engineers desired by the 141 reporting cities for their 1954 programs involving in total a capital outlay of about $210 MILLION

In comparing the data from the cities with that from the states for the distribution of 1954 employees among the several areas of activity, the principal differences are in planning and traffic, where the city average is 16 percent and the state average is 6 percent, and in construction, where the city average is 28 percent and the state average is 40 percent. The percentages for all areas are shown in Table A.

TABLE A

PERCENTAGE DISTRIBUTION OF EMPLOYEES ON THE ROLLS IN 1954

Area of Activity	Averages for the Cities					Averages for the States
	Group I	Group II	Group III	Group IV	All Groups	
	%	%	%	%	%	%
Planning and Traffic	20	15	16	16	16	6
Location and Design	34	30	27	27	28	28
Bridge Design	3	5	9	14	11	8
Construction	20	25	27	30	28	40
Materials and Testing	3	5	3	6	4	7
Maintenance	13	10	5	5	6	6
Other	7	10	13	2	7	5
Total	100	100	100	100	100	100

Reports from the cities show that 65 percent of them are using consultants. This figure for the states is 67 percent. The average distributions among areas of activity of positions affected by consultants are quite different in planning and traffic, where the city average is 13 percent and the state average is 3 percent, in street or road design, where the city average is 25 percent and the state average is 71 percent (including location), and in bridge design, where the city average is 36 percent and the state average is 18 percent. Percentages for all areas are shown in Table B.

TABLE B

PERCENTAGE DISTRIBUTION OF POSITIONS AFFECTED BY CONSULTANTS

Area of Activity	Averages for the Cities					Averages for the States
	Group I	Group II	Group III	Group IV	All Groups	
	%	%	%	%	%	%
Planning and Traffic	20	13	14	10	13	3
Location and Design	20	26	28	23	25	71
Bridge Design	15	25	24	56	36	18
Construction	12	16	12	3	9	5
Materials and Testing	8	16	11	1	8	1
Maintenance	3	0	1	0	1	0
Other	22	4	10	7	8	2
Total	100	100	100	100	100	100

The present shortage in the cities is 42 percent of the number on the rolls. The corresponding figure for the states is 22 percent.

The 141 cities reported a total of 631 engineering positions expected to be vacated by retirement in the next 10 years, which is 31 percent of the number on the rolls. The corresponding figure for the states is 18 percent.

The differences between the cities and the states are, in general, less for the larger cities, but even there the patterns are not similar.

1954 ENGINEERING-PERSONNEL SITUATION IN CONSULTING FIRMS

Questionnaires were sent to 150 consulting firms engaged in highway engineering. Reasonably complete replies were received from 64 firms and these form the bases of this phase of the study. The total number of engineers reported to be engaged in street and highway work in 1954 by these 64 consulting firms is 2,366. Letters were received from six additional firms giving the total number of engineers employed in 1954 but providing no information concerning distribution among areas of activity or needs for expanded programs. Including these six consulting firms, the total number of engineers engaged in highway work in 1954 would be raised to 3,100.

The state headquarters of the 64 consulting firms and the numbers of engineers on their rolls in 1954 is shown in Table C.

TABLE C

REPORTS RECEIVED FROM CONSULTING FIRMS

State	Number of Replies	Number of Engineers on the Rolls in 1954
Alabama	2	58
California	1	7
Florida	1	18
Georgia	1	33
Illinois	6	295
Iowa	1	7
Kansas	3	57
Maryland	2	147
Massachusetts	2	149
Minnesota	3	13
Missouri	3	92
Nebraska	1	18
New Hampshire	1	1
New Jersey	2	112
New Mexico	1	12
New York	12	750
North Dakota	1	2
Ohio	1	21
Oklahoma	4	54
Pennsylvania	7	394
Rhode Island	3	111
Texas	2	4
Vermont	1	2
Virginia	2	11
West Virginia	1	8
	64	2,366

Many of the firms are active in a number of states and are engaged in highway work for toll road authorities, counties and cities, as well as for the states.

The percentage distributions among areas of activity from reports of consulting firms and from reports of the cities and state highway departments on positions affected by consultants and on their own employees are shown in Table D.

TABLE D

COMPARISON OF DATA REPORTED BY CONSULTANTS, CITIES AND STATES

Area of Activity	Consultants	Positions Affected by Consultants: Cities	Positions Affected by Consultants: States	Engineers on the Rolls in 1954: Cities	Engineers on the Rolls in 1954: States
	%	%	%	%	%
Planning and Traffic	7	13	3	16	6
Location	15	-	3	-	5
Road (Street) Design	19	25	68	28	23
Bridge Design	28	36	18	11	8
Construction	18	9	5	28	40
Materials and Testing	5	8	1	4	7
Maintenance	0	1	0	6	6
Other	8	8	2	7	5
Total	100	100	100	100	100

The lack of agreement in these data may be attributed to incomplete returns and the fact that the consultants are engaged in highway work for toll road authorities and counties as well as for cities and states. The consultants' reports indicate that of the 2,366 engineers on their rolls engaged in highway engineering, 29 percent are on state highway work, 3 percent on county highway work, 9 percent on municipal street and highway work, and 59 percent on toll roads and other public works.

Returns from the 64 consulting firms show a need for a total of 509 additional engineers to work at the highest level of effectiveness on their 1954 programs with a distribution among areas of activity quite close to that for present employees. The additional need reported for planning and traffic is 16 percent of the number on the rolls, for location 20 percent, for road design 26 percent, for bridge design 22 percent, for construction 20 percent, for materials and testing 29 percent and for "other" 15 percent. The overall shortage is 21 percent of the number on the consultants' rolls, which compares with 22 percent for the states and 42 percent for the cities.

The number of engineering positions expected to be vacated by retirement in the next 10 years reported by the 64 firms totals 100, which is 4 percent of the number on the rolls—much less than the 31 percent reported by the cities and 18 percent reported by the states.

TABLE E

REPORTS RECEIVED FROM TOLL ROAD AUTHORITIES

Reported by	No. of Engineers on Rolls in 1954	No. of Positions Affected by Consultants	Remarks
Florida State Turnpike Authority	0	0	In preliminary stage
Georgia Turnpike Authority	0	0	Inactive
Illinois Toll Highway Commission	0	175	
Louisiana Expressway Authority	0	0	Inactive
Maine Turnpike Authority	6	40	
Michigan Turnpike Authority	1	25	
New Jersey Turnpike Authority	Not reported	Not reported	
Ohio Turnpike Commission	12	150 approx	
Texas Turnpike Authority	4	121	
Wisconsin Turnpike Authority	0	0	Inactive
Totals	23	511	

1954 ENGINEERING-PERSONNEL SITUATION IN TOLL-ROAD AUTHORITIES

Replies were received from 10 of the 21 toll-road authorities covered in the canvass. A tabulation of these replies is shown in Table E.

As indicated by the data shown in Table E, consultants are used extensively by toll-road authorities. Distribution among areas of activity varies with the stage of the program, being heaviest in planning and location in the initial stages and heaviest in design and construction in later stages. The reported data are not sufficient to support any conclusions other than these.

ESTIMATED ENGINEER REQUIREMENTS FOR EXPANDED PROGRAMS

Data submitted by the states, the District of Columbia, Hawaii, and Puerto Rico for programs 50 percent and 100 percent larger than their 1954 programs are shown in Tables 4 through 9.

The minimum number of engineers needed in total for programs 50 percent larger than in 1954, as shown in Table 4, is 26,721. This total exceeds the total number of engineers now on the rolls by 8,687, or 48 percent. The average distribution among areas of activity is about the same as for those on the rolls in 1954.

The minimum number of engineers needed in total for programs 100 percent larger than in 1954, as shown in Table 5, is 32,086. This exceeds the total now on the rolls by 14,052, or 78 percent. Again there is no significant change in distribution among areas of activity.

Optimum numbers of engineers desired for programs 50 percent and 100 percent larger than in 1954 are shown in Tables 6 and 7 and are in total 12 percent and 13 percent greater than the corresponding minimum totals shown in Tables 4 and 5.

Tables 8 and 9 show the extent to which consultants would be used in programs 50-percent and 100-percent larger than in 1954. These are tentative indications only and probably minimums, since consultants doubtless would be called upon to take on additional work for highway departments unable to handle the larger programs with their own forces. As shown in Table 8, it is estimated that, for programs 50-percent

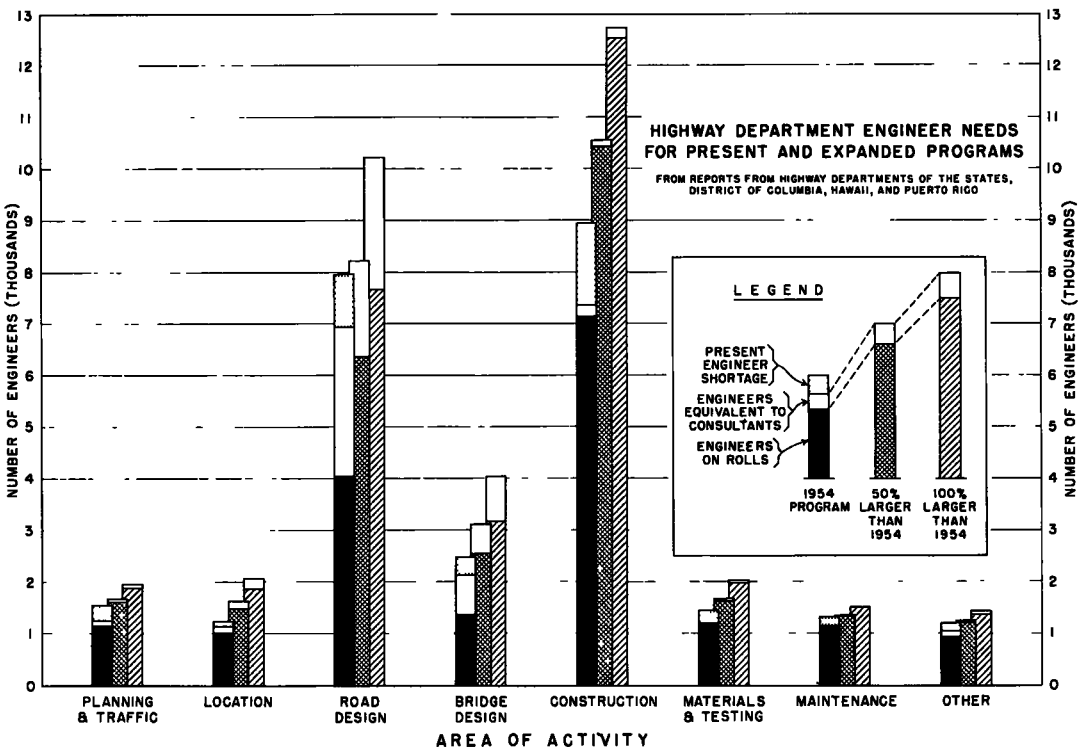

Figure 3.

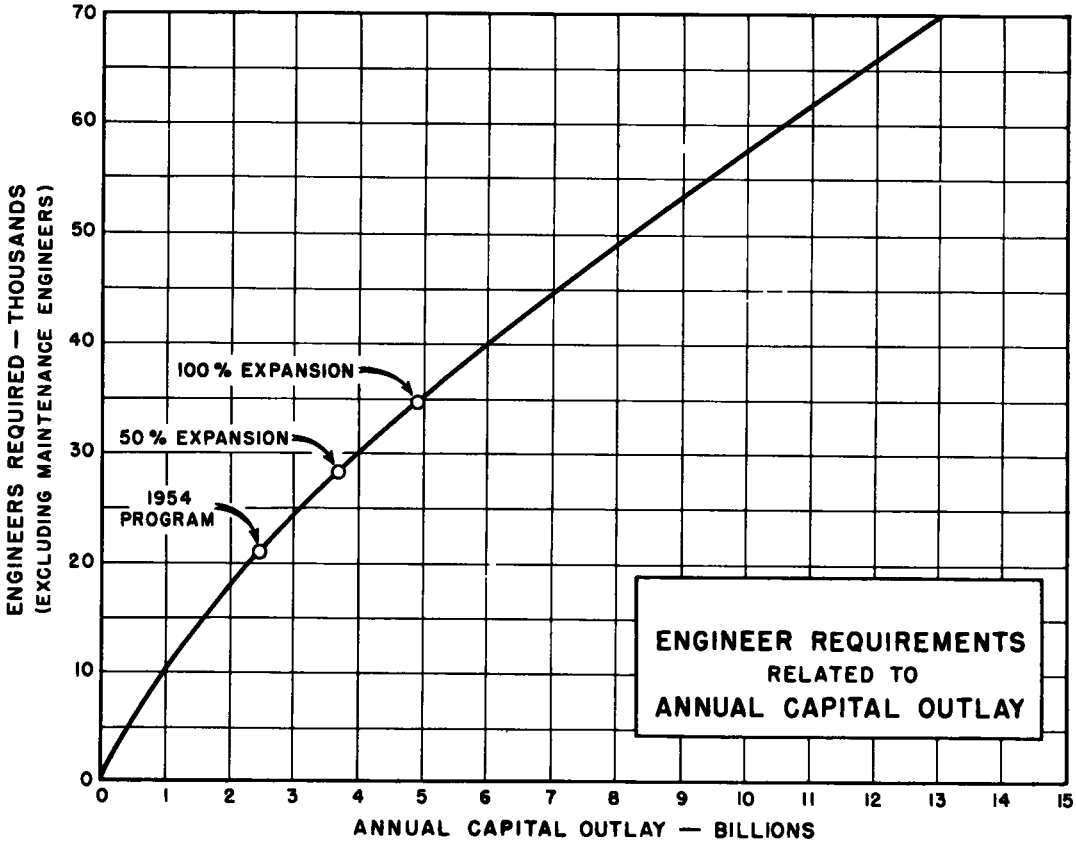

Figure 4.

larger than in 1954, consultants would be used to handle work that would otherwise require the employment by the highway departments of 2,790 additional engineers. For programs 100-percent larger than in 1954, the number is 3,952, as shown in Table 9. These numbers added to the corresponding minimum numbers of engineer employees needed by the highway departments for programs 50-percent and 100-percent larger, as shown in Tables 4 and 5, give estimated minimum total requirements of 29,511 engineers for 50-percent-larger programs and 36,038 engineers for 100-percent-larger programs. For 1954, the sum of the engineers on the rolls and the number equivalent to work done by consultants, from Tables 1 and 2, is 22,226. The increase for a 50-percent-larger program is 33 percent; for a 100-percent-larger program, 62 percent.

This situation is shown graphically by Figure 3, in which the totals have been distributed among the several areas of activity as reported. The greatest needs are in the areas of road design and construction and the least in the areas of maintenance and "other."

Table 10 shows that between 3,000 and 4,000 losses due to retirement are expected in the 10-year period from 1955 through 1964. These are necessarily general estimates and in a number of cases include only compulsory retirements.

In the canvass of the cities, additional needs are based on program expansions of 25 percent and 50 percent. For a 25-percent expansion, the 141 reporting cities estimate a minimum total need of 2,913 engineers, or 44 percent more than the number now on the rolls. For a 50-percent expansion, the reported minimum total need is 3,592, engineers, or 78 percent more than are now on the rolls. (The percentage increases reported by the states for 50-percent and 100-percent expansions, as previously noted, are 48 percent and 78 percent.) The percentage increases are above average for Groups I, II, and IV and

TABLE F

AVERAGE PERCENTAGE INCREASE IN NUMBER OF EMPLOYEES REPORTED FOR EXPANDED PROGRAMS

Percentage Expansion	Population Groups				
	Group I	Group II	Group III	Group IV	All Groups
25%	59%	45%	40%	48%	44%
50%	103%	90%	71%	80%	78%

below average for Group III, as shown in Table F.

The percentage distribution among the several areas of activity is about the same as for those on the rolls in 1954. The optimum numbers of engineers desired by the reporting cities for programs 25 percent and 50 percent larger than in 1954 are, in total, 19 percent and 20 percent greater than the corresponding minimum totals.

The reporting cities estimate that consultants would be used for work that would otherwise require the employment of 545 additional engineers for a 25-percent expansion of their program and 818 additional engineers for a 50-percent expansion. The sum of the engineers on the rolls and the number equivalent to work handled by consultants is 2,561 for the 1954 program. This figure for a 25-percent expansion is estimated by the cities to be 3,458 (minimum) and, for a 50 percent expansion, 4,410 (minimum). While there is some variation in the four population groups, the largest increases generally are in street design, bridge design, and construction.

In the canvass of consulting firms, additional needs are based on program expansions of 50 percent and 100 percent as in the case of the states. The reported data are shown, together with the distribution of engineers on the rolls in 1954, in Table G

The minimum number of engineers required for a 50-percent expanded program is 46 percent more than the number on the rolls in 1954. For a 100-percent expanded program, the minimum increase is 86 percent. Corresponding figures based on reports from the states are 48 percent and 78 percent. The optimum numbers desired for 50-percent and 100-percent expanded programs are 23 percent and 31 percent greater than the corresponding minimums.

The situation in the toll-road authorities is different from that in the other reporting organizations in that the 50-percent and 100-percent program-expansion bases for estimating future needs are not applicable. Some of the toll-road authorities have no work under way at the present time but are expecting to begin large programs in the near future, others are completing present programs and have no further work planned, and in one case the preliminary study showed the proposed project to be unfeasible.

The discussion up to this point represents the engineer-personnel situation as reported by the highway departments of the states, the District of Columbia, Hawaii, and Puerto Rico, about 70 percent of the cities with populations of 50,000 or more and substantial samples of consulting firms and toll road authorities.

TABLE G

Area of Activity	1954 Program	Minimum Required for Expanded Program		Optimum Desired for Expanded Program	
		25% Exp.	50% Exp.	25% Exp.	50% Exp.
Planning and Traffic	159	234	298	304	407
Location	351	547	722	692	963
Road Design	465	707	913	869	1203
Bridge Design	660	915	1165	1114	1510
Construction	438	632	790	766	996
Materials and Testing	111	171	229	217	307
Other	182	243	286	293	369
Total	2366	3449	4403	4255	5755

ESTIMATING FUTURE ENGINEER REQUIREMENTS

Because returns from the states are complete and returns from the cities, consultants, and toll-road authorities are not complete, future needs are estimated on the basis of the information received from the states. The major part of the engineering work for an expanded program will probably be handled directly by the states. Estimates of additional needs for expanded programs reported by the other organizations appear to be reasonably close to those reported by the states, viewed in the light of probable proportionate expansions. It appears, therefore, that results obtained in estimating future needs in this way should be more reliable than if an attempt were made to expand the incomplete returns to approximate complete coverage and to weight the figures for each type of reporting organization in accordance with a hypothetical distribution of the work volume resulting from an expanded program.

In the program proposed by President Eisenhower's Advisory Committee on a National Highway Program, as in any program based on actual needs, the degree of expansion will vary from state to state. One state's part of the total program may be 80 percent larger than its present program, while for another state the increase may be 150 or 200 percent.

However, the data obtained in the canvass, of the states, showing the numbers of engineers needed for the 1954 program and for programs 50 percent and 100 percent larger, combined with corresponding capital outlay amounts, establish a relationship between annual capital outlay and engineers required which can be applied to proposed program capital outlays to determine probable total engineer needs for those amounts.

This has been done in the following way: On a graph with annual capital outlay and number of engineers required as coordinates, three points were plotted. The first point was plotted using the sum of the total number of engineers employed by the highway departments in 1954 (from Table 1) and the total number of engineers equivalent to work done by consultants in 1954 (from Table 2) as the ordinate and the 1954 total capital outlay by the highway departments as the abscissa. The second point was plotted using the sum of the total minimum number of engineers estimated to be required for a program 50-percent larger than in 1954 (from Table 4) and the total number of engineers estimated to be equivalent to work which would be handled by consultants in a 50-percent larger program (from Table 8) as the ordinate and a capital outlay 50-percent greater than the 1954 amount as the abscissa. The third point was plotted in the same way using figures for a 100-percent expansion (from Tables 5 and 9).

These three points determined a curve which represents the relationship between annual capital outlay and minimum number of engineers required for a range of capital outlay from about $2½ billion to $5 billion based on the data reported by the highway departments. The curve was extended to the zero point on the left and extended to the right as a curve of constantly increasing radius finally becoming a straight line. The result is shown in Figure 4. For any given annual capital outlay the number of engineers required may be determined from the curve. For example: for a $10-billion annual capital outlay, a need of about 58,000 engineers is indicated.

Since neither the 1954 capital outlay nor the capital outlay contemplated in the proposed program includes maintenance costs, the numbers of engineers used in the calculation exclude maintenance engineers, and the engineer requirements as determined from the curve exclude maintenance engineers.

APPARENT VARIATIONS IN STATE PRACTICES

The results obtained in this way are approximate, not only because of projecting the curve but also because of the variable and indeterminate factors involved. For example, the relationship between size of program and engineers needed is based on state-highway-department practices, whereas segments of an expanded program will be handled by consultants, cities, counties, and local jurisdictions.

Among the states themselves the results of the canvass reveal what appear to be appreciable differences in operating efficiencies as indicated by the ratio of the number of engineers employed (excluding maintenance engineers) per million dollars of capital outlay. For the 1954 programs this ratio ranges from 2.0 to 28.2 with no

TABLE 11

NUMBER OF PROFESSIONAL ENGINEERS EMPLOYED IN 1954
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Street Traffic	Bridge Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	0	0	0	0	0	1	0	1
Calif Alhambra	53, 558	2	0	0	0	0	0	0	2
Stockton	70, 853	1	1	-	-	-	-	-	2
Col Pueblo	63, 685	1	1	0	-	-	-	-	2
Ga Augusta	71, 508	1	2	-	2	-	1	-	6
Ill Aurora	50, 576	0	1	0	1	0	0	0	2
Joliet	51, 601	-	1	-	-	-	-	-	1
Iowa Cedar Rap	72, 296	-	2	-	1	-	-	1	4
Ky Lexington	55, 534	1	-	-	-	-	3	-	4
Mass Pittsfield	53, 348	1	6	-	-	-	-	-	7
Mich Kalamazoo	57, 704	2	1	0	1	-	1	-	5
Pontiac	73, 681	0	1	0	1	0	1	0	3
Mo Springfield	66, 731	-	1	-	1	-	1	3	6
N J Atlantic C	61, 657	-	2	-	-	-	-	-	2
Clifton	64, 511	-	-	-	-	-	-	-	-
Passaic	57, 702	1½	½	0	1	½	½	1	5
N Y New Roch'l	59, 725	1	1	-	1	-	-	1	4
Troy	72, 311	-	1	-	-	-	-	-	1
N C Raleigh	65, 679	1	1	0	1	0	1	0	4
Ohio Hamilton	57, 951	1	1	0	1	0	0	0	3
Lima	50, 246	-	-	-	0	-	-	0	0
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55, 060	1	1	0	1	0	0	0	3
S C Charleston	70, 174	0	1	-	1	-	1	0	3
Greenville	58, 161	0	1	0	1	0	0	0	2
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	3	3	1	4	0	1	1	13
Utah Ogden	57, 112	1	1	0	-	3	-	-	5
Va Alexandria	61, 787	0	1	1	0	0	1	0	3
Wis Green Bay	52, 735	1	1	1	1	0	0	0	4
Racine	71, 193	-	1	-	1	-	1	-	3
Total		20½	36½	3	21	3½	13½	7	105

TABLE 12

NUMBER OF ENGINEERING POSITIONS AFFECTED BY CONSULTANTS
Group I Cities (Population 50, 000 to 75, 000

State and City	Pop	Plan & Street Bridge Traffic	Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	0	½	½	1	0	0	0	2
Calif Alhambra	53, 558	0	0	0	0	0	0	3	3
Stockton	70, 853	-	-	1	-	-	-	-	1
Col Pueblo	63, 685	1	1	0	1	0	1	0	4
Ga Augusta	71, 508	-	1	-	-	-	-	-	1
Ill Aurora	50, 576	-	-	1	-	1	-	-	2
Joliet	51, 601	-	-	-	1	-	-	-	1
Iowa Cedar Rap	72, 296	-	-	-	-	-	-	-	-
Ky Lexington	55, 534	-	-	-	-	-	-	-	-
Mass Pittsfield	53 348	0	0	0	0	0	0	0	0
Mich Kalamazoo	57, 704	0	0	1	0	0	0	-	1
Pontiac	73 681	0	0	1	0	1	0	0	2
Mo Springfield	66, 731	1	-	-	-	-	-	1	2
N J Atlantic C	61, 657	-	-	-	-	-	-	-	-
Clifton	64, 511	-	-	-	-	-	-	-	-
Passaic	57, 702	0	0	0	0	0	0	0	0
N Y New Roch'l	59, 725	1	½	-	½	-	-	-	2
Troy	72, 311	-	-	1	-	-	-	-	1
N C Raleigh	65, 679	1	0	-	0	1	-	-	2
Ohio Hamilton	57 951	0	0	0	0	0	0	1	1
Lima	50, 246	0	-	-	-	-	-	-	-
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55 060	1	1	0	0	0	0	0	2
S C Charleston	70, 174	1	0	0	0	0	0	0	1
Greenville	58, 161	0	0	0	0	0	0	3	3
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	0	0	0	0	0	0	0	0
Utah Ogden	57, 112	-	0	0	-	0	-	-	0
Va Alexandria	61, 787	-	-	-	-	-	-	-	0
Wis Green Bay	52, 735	-	-	-	-	-	-	-	0
Racine	71, 193	0	0	0	0	0	0	0	0
Total		7	7	5½	4½	3	1	8	36

TABLE 13

NUMBER OF PROFESSIONAL ENGINEERS DESIRED IN ADDITION TO (1) AND (2)
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Street Bridge Traffic	Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	½	0	0	0	0	0	½	1
Calif Alhambra	53, 558	0	0	0	0	0	0	0	0
Stockton	70, 853	-	-	-	1	1	-	-	2
Col Pueblo	63, 685	2	2	2	2	2	-	-	10
Ga Augusta	71, 508	1	2	-	2	-	1	-	6
Ill Aurora	50, 576	-	1	-	1	-	-	-	2
Joliet	51, 601	-	1	-	1	-	1	-	3
Iowa Cedar Rap	72, 296	-	-	-	-	-	-	-	-
Ky Lexington	55, 534	-	-	-	-	-	1	1	2
Mass Pittsfield	53, 348	1	1	1	-	-	-	-	3
Mich Kalamazoo	57, 704	-	1	-	1	-	-	-	2
Pontiac	73, 681	1	1	0	1	0	0	0	3
Mo Springfield	66, 731	1	2	-	-	-	-	2	5
N J Atlantic C	61, 657	-	1	-	-	-	-	-	1
Clifton	64, 511	-	-	-	-	-	-	-	0
Passaic	57, 702	½	½	1	0	0	0	0	2
N Y New Roch'l	59, 725	½	-	-	½	-	-	-	1
Troy	72, 311	2	1	1	1	-	1	-	6
N C Raleigh	65, 679	1	0	-	0	0	0	-	1
Ohio Hamilton	57, 951	-	-	-	-	-	-	-	0
Lima	50, 246	-	1	-	1	-	-	1	3
Pa Chester	66, 039	0	0	0	0	0	0	0	0
R I Cranston	55, 060	2	2	0	4	0	0	0	8
S C Charleston	70, 174	1	1	-	1	-	-	0	3
Greenville	58, 161	1	0	1	0	0	0	0	2
S D Sioux F	52, 696	-	1	-	1	1	-	-	3
Tex Lubbock	71, 747	1	0	0	0	0	0	1	2
Utah Ogden	57, 112	0	1	0	0	2	0	0	3
Va Alexandria	61, 787	2	0	0	1	0	0	0	3
Wis Green Bay	52, 735	0	1	0	1	0	0	0	2
Racine	71, 193	0	0	0	0	0	0	0	0
Total		17½	20½	6	19½	6	4	6½	80

TABLE 14

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Street Bridge Traffic	Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	-	-	-	½	-	2	-	2½
Calif Alhambra	53, 558	1	1	1	1	-	-	1	5
Stockton	70, 853	1	1	-	1	-	-	-	3
Col Pueblo	63, 685	2	2	-	2	2	2	-	10
Ga Augusta	71, 508	1	2	-	3	-	1	-	7
Ill Aurora	50, 576	-	2	-	1	-	-	-	3
Joliet	51, 601	-	2	-	2	-	1	-	5
Iowa Cedar Rap	72, 296	-	2	-	1	-	-	1	4
Ky Lexington	55, 534	1	-	-	-	-	3	1	5
Mass Pittsfield	53, 348	1	6	-	-	-	-	-	7
Mich Kalamazoo	57, 704	2	2	-	2	-	1	-	7
Pontiac	73, 681	1	2	-	3	-	1	-	7
Mo Springfield	66, 731	1	2	-	1	-	-	1	5
N J Atlantic C	61, 657	-	3	-	-	-	-	-	3
Clifton	64, 511	-	1	-	-	-	-	2	3
Passaic	57, 702	2	1	1	1½	1	½	1	8
N Y New Roch'l	59, 725	2	1	-	1	-	-	1	5
Troy	72, 311	-	1	-	-	-	-	-	1
N C Raleigh	65, 679	2	2	-	2	-	1	-	7
Ohio Hamilton	57, 951	1	1	-	1	-	-	-	3
Lima	50, 246	-	-	-	1	-	-	1	2
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55, 060	2	3	-	4	-	-	-	9
S C Charleston	70, 174	2	1	-	1	-	1	-	5
Greenville	58, 161	-	1	-	1	-	-	-	2
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	3	3	1	5	-	1	1	14
Utah Ogden	57, 112	-	3	-	7	4	-	-	14
Va Alexandria	61, 787	1	1	1	1	-	1	-	5
Wis Green Bay	52, 735	2	2	1	2	-	-	-	7
Racine	71, 193	-	1	-	2	-	1	-	4
Total		29	52	5	48	7	16½	10	167½

TABLE 15

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Street Bridge Traffic	Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	-	-	-	1	½	2	1	4½
Calif Alhambra	53, 558	1	2	1	1	-	-	1	6
Stockton	70, 853	1	2	-	-	1	-	-	4
Col Pueblo	63, 685	2	2	-	2	2	2	-	10
Ga Augusta	71, 508	1	3	-	5	-	2	-	11
Ill Aurora	50, 576	-	2	-	1	-	-	-	3
Joliet	51, 601	-	3	-	3	-	2	-	8
Iowa Cedar Rap	72, 296	-	3	-	2	-	-	1	6
Ky Lexington	55, 534	1	-	-	-	-	3	2	6
Mass Pittsfield	53 348	2	7	1	-	-	-	-	10
Mich Kalamazoo	57, 704	3	2	-	2	-	2	-	9
Pontiac	73, 681	1	2	-	3	-	2	-	8
Mo Springfield	66, 731	2	3	-	2	-	-	2	9
N J Atlantic C	61, 657	-	4	-	-	-	-	-	4
Clifton	64, 511	-	2	-	-	-	-	4	6
Passaic	57, 702	2	1	1	1½	1	½	1	8
N Y New Roch'l	59, 725	2	1	-	1	-	-	1	5
Troy	72, 311	-	1	-	-	-	-	-	1
N C Raleigh	65, 679	2	2	1	2	-	1	-	8
Ohio Hamilton	57, 951	1	1	-	1	-	-	-	3
Lima	50, 246	-	-	-	2	-	-	1	3
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55, 060	2	4	-	6	-	-	-	12
S C Charleston	70, 174	3	1	-	2	-	1	-	7
Greenville	58, 161	-	1	-	1	1	1	-	4
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	3	4	2	5	-	1	2	17
Utah Ogden	57, 112	-	4	-	9	4	-	-	17
Va Alexandria	61, 787	2	2	1	2	-	1	-	8
Wis Green Bay	52, 735	2	2	1	2	-	-	-	7
Racine	71, 193	-	1	-	2	-	1	-	4
Total		34	65	8	59½	9½	21½	16	213½

TABLE 16

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Street Bridge Traffic	Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	½	-	-	½	-	2	½	3½
Calif Alhambra	53, 558	1	2	2	-	-	-	1	6
Stockton	70, 853	1	1	-	2	1	-	-	5
Col Pueblo	63, 685	2	2	2	2	2	2	-	12
Ga Augusta	71, 508	1	4	-	5	-	2	-	12
Ill Aurora	50, 576	-	2	-	2	-	-	-	4
Joliet	51, 601	-	2	-	2	-	1	-	5
Iowa Cedar Rap	72, 296	-	2	-	1	-	-	1	4
Ky Lexington	55, 534	1	-	-	-	-	3	1	5
Mass Pittsfield	53, 348	2	7	1	-	-	-	-	10
Mich Kalamazoo	57, 704	3	2	-	3	-	2	-	10
Pontiac	73, 681	1	3	-	3	-	2	-	9
Mo Springfield	66, 731	2	3	-	2	-	-	1	8
N J Atlantic C	61, 657	-	3	-	-	-	-	-	3
Clifton	64, 511	-	1	-	-	-	-	2	3
Passaic	57, 702	2	1	1	1½	1	1½	1	8
N Y New Roch'l	59, 725	2	1	-	1	-	-	2	6
Troy	72, 311	-	1	-	-	-	-	-	1
N C Raleigh	65, 679	2	2	1	2	1	2	-	10
Ohio Hamilton	57, 951	1	1	-	1	-	-	-	3
Lima	50, 246	-	-	-	2	-	-	1	3
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55, 060	2	4	-	6	-	-	-	12
S C Charleston	70, 174	2	1	-	1	-	1	1	6
Greenville	58, 161	1	1	1	1	-	-	-	4
S D Sioux F	52, 696	1	3	-	1	1	-	-	6
Tex Lubbock	71, 747	3	5	1	5	-	1	2	17
Utah Ogden	57, 112	-	3	-	8	4	-	-	15
Va Alexandria	61, 787	2	2	1	2	-	2	-	9
Wis Green Bay	52, 735	2	2	-	2	-	-	-	7
Racine	71, 193	-	1	-	2	-	1	-	4
Total		34½	63	12	59	10	21½	13½	213½

TABLE 17

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	½	-	-	-	-	3	½	4
Calif Alhambra	53, 558	1	3	2	-	-	-	1	7
Stockton	70, 853	1	2	-	1	2	1	-	7
Col Pueblo	63, 685	2	2	2	2	2	2	-	12
Ga Augusta	71, 508	2	5	-	7	-	3	-	17
Ill Aurora	50, 576	-	2	-	2	-	-	-	4
Joliet	51, 601	-	3	-	3	-	2	-	8
Iowa Cedar Rap	72, 296	-	3	-	2	-	-	1	6
Ky Lexington	55, 534	1	-	-	1	-	4	2	8
Mass Pittsfield	53, 348	2	7	1	-	-	-	-	10
Mich Kalamazoo	57, 704	3	3	1	4	-	3	-	14
Pontiac	73, 681	1	2	-	4	-	2	-	9
Mo Springfield	66, 731	3	4	-	3	-	-	2	12
N J Atlantic C	61, 657	-	4	-	-	-	-	-	4
Clifton	64, 511	-	2	-	-	-	-	4	6
Passaic	57, 702	2	1	1	1½	1	½	1	8
N Y NewRoch'l	59, 725	2	1	-	1	-	-	2	6
Troy	72, 311	-	1	-	-	-	-	-	1
N C Raleigh	65, 679	2	2	1	3	2	2	-	12
Ohio Hamilton	57, 951	1	1	-	1	-	-	-	3
Lima	50, 246	-	-	-	3	-	-	2	5
Pa Chester	66, 039	-	1	-	1	-	-	-	2
R I Cranston	55, 060	3	6	-	9	-	-	-	18
S C Charleston	70, 174	3	1	-	2	-	1	1	8
Greenville	58, 161	1	2	1	2	-	1	-	7
S D Sioux F	52, 696	1	3	-	1	1	-	-	6
Tex Lubbock	71, 747	4	5	1	5	-	1	3	19
Utah Ogden	57, 112	-	4	-	10	5	-	-	19
Va Alexandria	61, 787	2	2	1	2	-	2	-	9
Wis Green Bay	52, 735	2	2	1	2	-	-	-	7
Racine	71, 193	-	1	-	2	-	1	-	4
Total		39½	75	12	74½	13	28½	19½	262

TABLE 18

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 25 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	½	½	½	½	½	-	-	2½
Calif Alhambra	53, 558	-	-	-	-	1	-	-	1
Stockton	70, 853	-	-	1	-	-	-	-	1
Col Pueblo	63, 685	-	-	-	-	-	-	-	-
Ga Augusta	71, 508	-	-	-	-	-	-	-	-
Ill Aurora	50, 576	-	-	1	-	1	-	-	2
Joliet	51, 601	-	-	-	-	-	-	-	-
Iowa Cedar Rap	72, 296	-	-	-	-	-	-	-	-
Ky Lexington	55, 534	-	-	-	-	-	-	-	-
Mass Pittsfield	53, 348	-	-	-	-	-	-	-	-
Mich Kalamazoo	57, 704	-	1	1	-	-	-	-	2
Pontiac	73, 681	-	-	1	-	1	-	-	2
Mo Springfield	66, 731	-	-	-	-	-	3	3	
N J Atlantic C	61, 657	-	-	-	-	-	-	-	-
Clifton	64, 511	-	-	-	-	-	-	-	-
Passaic	57, 702	1	½	½	-	-	-	-	2
N Y New Roch'l	59, 725	-	-	-	1	-	-	-	1
Troy	72, 311	-	2	1	2	1	1	-	7
N C Raleigh	65, 679	2	-	1	-	1	-	-	4
Ohio Hamilton	57, 951	-	-	-	-	-	-	1	1
Lima	50, 246	-	-	-	-	-	-	-	-
Pa Chester	66, 039	-	1	-	-	-	-	-	1
R I Cranston	55, 060	-	-	-	-	-	-	-	-
S C Charleston	70, 174	-	-	-	-	-	-	-	-
Greenville	58, 161	-	-	-	-	-	-	2	2
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	-	-	-	-	-	-	-	-
Utah Ogden	57, 112	-	-	-	-	-	-	-	-
Va Alexandria	61, 787	-	-	-	-	-	-	-	-
Wis Green Bay	52, 735	-	-	-	-	-	-	-	-
Racine	71, 193	-	1	-	-	-	-	-	1
Total		4½	7	7	3½	5½	1	6	34½

TABLE 19

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 50 PERCENT
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	1	1	½	1	½	-	-	4
Calif Alhambra	53, 558	-	-	-	-	1	-	-	1
Stockton	70, 853	-	-	1	1	-	-	-	2
Col Pueblo	63, 685	-	-	-	-	-	-	-	-
Ga Augusta	71, 508	-	-	-	-	-	-	-	-
Ill Aurora	50, 576	-	-	1	-	1	-	-	2
Joliet	51, 601	-	-	-	-	-	-	-	-
Iowa Cedar Rap	72, 296	-	-	-	-	-	-	-	-
Ky Lexington	55, 534	-	1	-	-	-	-	-	1
Mass Pittsfield	53, 348	-	-	-	-	-	-	-	-
Mich Kalamazoo	57, 704	-	1	1	-	-	-	-	2
Pontiac	73, 681	-	1	1	1	-	-	-	4
Mo Springfield	66, 731	-	-	-	-	-	-	4	4
N J Atlantic C	61, 657	-	-	-	-	-	-	-	-
Clifton	64, 511	-	-	-	-	-	-	-	-
Passaic	57, 702	2	1	1	-	-	-	-	4
N Y NewRoch'l	59, 725	-	-	-	1	-	-	-	1
Troy	72, 311	-	3	1	3	1	1	-	9
N C Raleigh	65, 679	3	1	1	-	1	-	-	6
Ohio Hamilton	57, 951	-	-	-	-	-	-	1	1
Lima	50, 246	-	-	-	-	-	-	-	-
Pa Chester	66, 039	-	1	-	-	-	-	-	1
R I Cranston	55, 060	-	-	-	-	-	-	-	-
S C Charleston	70, 174	-	-	-	-	-	-	-	-
Greenville	58, 161	1	-	-	-	-	-	2	3
S D Sioux F	52, 696	1	2	-	-	-	-	-	3
Tex Lubbock	71, 747	-	-	-	-	-	-	-	-
Utah Ogden	57, 112	-	-	-	-	-	-	-	-
Va Alexandria	61, 787	-	-	-	-	-	-	-	-
Wis Green Bay	52, 735	-	-	-	-	-	-	-	-
Racine	71, 193	-	1	-	-	-	-	-	1
Total		8	13	7½	7	5½	1	7	49

TABLE 20

NUMBER OF POSITIONS TO BE VACATED BY RETIREMENT DURING NEXT 10 YEARS
Group I Cities (Population 50, 000 to 75, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Ala Gadsen	55, 725	-	-	-	-	-	-	-	-
Calif Alhambra	53, 558	1	0	0	0	0	0	0	1
Stockton	70, 853	-	-	-	-	-	-	-	0
Col Pueblo	63, 685	-	-	-	-	-	-	-	0
Ga Augusta	71, 508	-	1	-	-	-	-	-	1
Ill Aurora	50, 576	-	-	-	-	-	-	-	-
Joliet	51, 601	-	1	-	-	-	-	-	1
Iowa Cedar Rap	72, 296	-	-	-	-	-	-	1	1
Ky Lexington	55, 534	-	-	-	-	-	1	-	1
Mass Pittsfield	53, 348	1	4	-	-	-	-	-	5
Mich Kalamazoo	57, 704	-	1	-	1	-	-	-	2
Pontiac	73, 681	-	-	-	1	-	1	-	2
Mo Springfield	66, 731	-	-	-	-	-	-	1	1
N J Atlantic C	61, 657	-	1	-	-	-	-	-	1
Clifton	64, 511	-	-	-	-	-	-	1	1
Passaic	57, 702	2	0	0	1	0	0	0	3
N Y NewRoch'l	59, 725	1	-	-	-	-	-	1	2
Troy	72, 311	-	-	-	-	-	-	2	2
N C Raleigh	65, 679	0	0	0	0	0	0	0	0
Ohio Hamilton	57, 951	-	-	-	-	-	-	-	0
Lima	50, 246	-	-	-	-	-	-	-	-
Pa Chester	66, 039	-	-	-	1	-	-	-	1
R I Cranston	55, 060	0	4	-	-	-	-	-	4
S C Charleston	70, 174	0	0	0	1	0	0	0	1
Greenville	58, 161	0	1	0	0	0	0	0	1
S D Sioux F	52, 696	-	-	-	-	-	-	-	0
Tex Lubbock	71, 747	0	0	0	1	0	0	0	1
Utah Ogden	57, 112	-	-	-	2	-	-	-	2
Va Alexandria	61, 787	0	0	1	0	0	0	0	1
Wis Green Bay	52, 735	-	-	-	-	-	-	-	0
Racine	71, 193	-	-	-	1	-	-	-	1
Total		5	13	1	9	0	3	8	36

TABLE 21

NUMBER OF PROFESSIONAL ENGINEERS EMPLOYED IN 1954
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88, 043	1	2	-	-	-	-	4	7
Fresno	91, 669	0	2	1	1	0	0	0	4
Glendale	95, 702	2	4	-	1	-	1	2	10
Richmond	99, 545	1	2	2	-	-	-	1	6
Fla St P'burg	96, 738	1	1	-	-	-	-	-	2
Ga Columbus	79, 611	-	1	-	1	-	1	-	3
Ind Hammond	87, 594	-	-	-	1	-	-	-	1
Iowa Sioux City	83, 991	0	3	1	0	0	1	2	7
Kans Topeka	78, 791	-	2	-	2	-	-	-	4
Me Portland	77, 634	1	1	-	2	-	1	-	5
Mass Lawrence	80, 536	-	1	-	1	-	-	-	2
Lowell	97, 249	-	1	-	1	-	1	-	3
Lynn	99, 738	1	1	0	1	0	0	1	4
Newton	81, 994	-	2	-	5	-	1	2	10
Quincy	83, 835	6	3	2	8	3	1	0	23
Mich Dearborn	94, 994	-	3	-	1	-	-	-	4
Lansing	92, 129	1	2	0	1	1	1	0	6
Saginaw	92, 918	1	2	0	1	1	0	0	5
Miss Jackson	98, 271	1	1	0	3	0	2	-	7
Mo St Joseph	78, 588	1	1	-	1	1	-	1	5
N H Manchester	82, 732	1	1	1	-	-	-	-	3
N J E Orange	79, 340	2	1	0	1	0	1	0	5
N M Albu'que	96, 815	1	1	-	-	-	-	-	2
N Y Binghamp'n	80, 674	0	1	1	1	0	0	0	3
Sch'dy	91, 785	1	2	0	0	2	0	2	7
N C Winst-Sal	87, 811	0	2½	1	1	0	1	0	5½
Pa Wilkes-B'e	76, 826	1	1	1	-	-	-	-	3
R I Pawtucket	81, 436	0	1	1	1	0	0	0	3
Tex Waco	84, 706	-	-	-	-	-	-	1	1
Va Portsm'th	80, 039	1	1	0	1	0	1	0	4
Roanoke	91, 921	1	5	-	5	-	3	-	14
W Va Huntington	86, 353	-	1	-	-	-	-	-	1
Total		25	52½	9	43	8	16	16	169½

TABLE 22

NUMBER OF ENGINEERING POSITIONS AFFECTED BY CONSULTANTS
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88, 043	-	-	-	-	-	-	-	0
Fresno	91, 669	0	0	0	0	1	0	0	1
Glendale	95, 702	-	3	1	1	1	-	-	6
Richmond	99, 545	1	1	-	-	-	-	1	3
Fla St P'burg	96, 738	-	-	-	-	-	-	-	-
Ga Columbus	79, 611	-	-	-	-	-	-	-	-
Ind Hammond	87, 594	1	-	1	-	1	-	-	3
Iowa Sioux City	83, 991	-	-	-	-	-	-	-	0
Kans Topeka	78, 791	-	4	-	-	-	-	-	4
Me Portland	77, 634	-	-	-	-	1	-	-	1
Mass Lawrence	80, 536	-	-	-	-	-	-	-	-
Lowell	97, 249	0	0	1	0	1	0	0	2
Lynn	99, 738	-	-	-	-	-	-	-	0
Newton	81, 994	-	-	-	-	-	-	-	-
Quincy	83, 835	6	5	6	8	3	0	0	28
Mich Dearborn	94, 994	-	-	-	-	-	-	-	0
Lansing	92, 129	-	-	3	-	1	-	-	4
Saginaw	92, 918	0	0	5	0	0	0	0	5
Miss Jackson	98, 271	0	1	1	0	0	0	-	2
Mo St Joseph	78, 588	-	-	-	2	-	-	-	2
N H Manchester	82, 732	1	1	1	-	-	-	-	3
N J E Orange	79, 340	0	0	0	0	1	0	1	2
N M Albu'que	96, 815	-	4	-	1	-	-	-	5
N Y Binghamp'n	80, 674	-	-	-	-	-	-	-	0
Sch'dy	91, 785	0	0	0	0	1	0	0	1
N C Winst-Sal	87, 811	1	0	0	0	0	0	0	1
Pa Wilkes-B'e	76, 826	-	-	-	-	-	-	-	-
R I Pawtucket	81, 436	1	0	0	0	0	0	0	1
Tex Waco	84, 706	-	-	-	-	-	-	-	0
Va Portsm'th	80, 039	0	1	1	0	0	0	1	3
Roanoke	91, 921	-	2	-	2	-	-	-	4
W Va Huntington	86, 353	-	-	-	-	2	-	-	2
Total		11	22	21	13	13	0	3	83

TABLE 23

NUMBER OF PROFESSIONAL ENGINEERS DESIRED IN ADDITION TO (1) AND (2)
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	-	1	-	-	-	-	1	2
Fresno	91,669	1	1	0	0	0	0	0	2
Glendale	95,702	1	1	1	-	1	-	-	4
Richmond	99,545	1	1	-	2	-	-	-	4
Fla St P'burg	96,738	-	1	-	-	-	-	-	1
Ga Columbus	79,611	-	-	-	-	-	-	-	-
Ind Hammond	87,594	1	-	1	-	-	-	-	2
Iowa Sioux City	83,991	0	3	1	0	0	1	2	7
Kans Topeka	78,791	1	1	-	1	-	-	-	3
Me Portland	77,634	1	1	-	1	-	-	-	3
Mass Lawrence	80,536	-	1	-	-	-	-	-	1
Lowell	97,249	1	1	0	0	0	0	0	2
Lynn	99,738	0	0	0	2	0	0	0	2
Newton	81,994	2	1	-	1	-	1	-	5
Quincy	83,835	5	6	3	5	3	2	0	24
Mich Dearborn	94,994	-	1	-	1	-	-	-	2
Lansing	92,129	-	-	-	-	-	-	-	0
Saginaw	92,918	0	1	0	1	0	1	0	3
Miss Jackson	98,271	0	1	0	-	0	1	-	2
Mo St Joseph	78,588	1	-	-	-	-	-	-	1
N H Manchester	82,732	1	2	1	2	-	1	-	7
N J E Orange	79,340	1	1	0	1	0	0	0	3
N M Albu'que	96,815	2	1	-	1	-	1	-	5
N Y Binghamp'n	80,674	1	0	0	0	0	0	0	1
Sch'dy	91,785	1	2	0	0	3	0	2	8
N C Winst-Sal	87,811	-	-	-	-	-	-	-	0
Pa Wilkes-B'e	76,826	1	-	-	-	-	-	-	1
R I Pawtucket	81,436	1	1	0	0	0	0	0	2
Tex Waco	84,706	1	1	-	1	1	-	-	4
Va Portsm'th	80,039	1	1	0	1	0	0	0	3
Roanoke	91,921	1	-	-	1	-	-	-	2
W Va Huntington	86,353	-	1	-	1	-	-	-	2
Total		25	32	7	22	8	8	5	107

TABLE 24

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	1	3	-	1	-	-	4	9
Fresno	91,669	2	2	-	1	-	-	-	5
Glendale	95,702	3	8	1	1	1	-	2	16
Richmond	99,545	1	2	-	2	1	-	1	7
Fla St P'burg	96,738	1	1	-	-	-	-	-	2
Ga Columbus	79,611	-	1	-	1	-	1	-	3
Ind Hammond	87,594	1	1	1	1	-	-	-	4
Iowa Sioux City	83,991	1	5	2	1	1	1	2	13
Kans Topeka	78,791	1	5	-	2	-	-	-	8
Me Portland	77,634	2	2	-	3	-	1	-	8
Mass Lawrence	80,536	-	1	-	1	-	-	-	2
Lowell	97,249	-	2	-	2	1	1	-	6
Lynn	99,738	1	1	-	1	-	-	1	4
Newton	81,994	2	3	-	6	-	2	2	15
Quincy	83,835	8	4	3	10	4	1	-	30
Mich Dearborn	94,994	-	3	-	1	-	-	-	4
Lansing	92,129	2	3	-	2	1	1	-	9
Saginaw	92,918	1	3	-	2	1	1	-	8
Miss Jackson	98,271	2	1	-	2	-	3	-	8
Mo St Joseph	78,588	2	3	-	4	2	-	2	13
N H Manchester	82,732	1	2	1	2	-	2	-	8
N J E Orange	79,340	2	2	-	2	-	-	-	6
N M Albu'que	96,815	4	1	-	-	-	2	-	7
N Y Binghamp'n	80,674	1	1	1	1	-	-	-	4
Sch'dy	91,785	1	2	-	-	3	-	2	8
N C Winst-Sal	87,811	1	3	1	1	-	1	-	7
Pa Wilkes-B'e	76,826	1	1	1	-	-	-	-	3
R I Pawtucket	81,436	1	2	1	1	-	-	-	5
Tex Waco	84,706	1	1	-	1	-	-	1	4
Va Portsm'th	80,039	1	1	-	1	-	1	-	4
Roanoke	91,921	2	3	-	6	-	2	1	14
W Va Huntington	86,353	-	1	-	-	-	-	-	1
Total		47	74	12	59	15	20	18	245

TABLE 25

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	2	3	-	1	-	-	5	11
Fresno	91,669	2	3	1	2	-	-	-	8
Glendale	95,702	3	10	1	1	1	1	2	19
Richmond	99,545	1	3	-	3	1	-	1	9
Fla St P'burg	96,738	1	2	-	-	-	-	-	3
Ga Columbus	79,611	-	1	-	1	-	1	-	3
Ind Hammond	87,594	2	1	2	2	1	-	-	8
Iowa Sioux City	83,991	1	6	3	2	1	1	2	16
Kans Topeka	78,791	1	5	-	2	-	-	-	8
Me Portland	77,634	3	3	-	4	-	2	-	12
Mass Lawrence	80,536	-	1	-	1	-	-	-	2
Lowell	97,249	1	3	-	3	1	1	-	9
Lynn	99,738	2	1	-	2	-	-	1	6
Newton	81,994	3	4	-	8	-	3	3	21
Quincy	83,835	9	5	4	12	5	2	0	37
Mich Dearborn	94,994	-	5	-	1	-	-	-	6
Lansing	92,129	2	4	-	2	1	1	-	10
Saginaw	92,918	1	4	-	2	1	1	-	9
Miss Jackson	98,271	2	1	-	2	-	3	-	8
Mo St Joseph	78,588	3	4	-	8	4	-	4	21
N H Manchester	82,732	2	3	1	4	-	3	-	13
N J E Orange	79,340	2	3	-	3	-	-	-	8
N M Albu'que	96,815	5	1	-	-	-	2	-	8
N Y Binghamp'n	80,674	2	1	2	1	-	-	-	6
Sch'dy	91,785	1	3	-	-	3	-	3	10
N C Winst-Sal	87,811	1	4	1	1	-	1	-	8
Pa Wilkes-B'e	76,826	1	1	1	-	1	-	-	4
R I Pawtucket	81,436	2	2	1	1	-	1	-	7
Tex Waco	84,706	1	1	1	1	1	-	1	6
Va Portsm'th	80,039	1	1	-	1	-	2	-	5
Roanoke	91,921	2	4	-	8	-	2	2	18
W Va Huntington	86,353	-	1	-	1	-	-	-	2
Total		59	94	18	78	21	27	24	321

TABLE 26

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	2	3	-	1	-	-	4	10
Fresno	91,669	2	3	-	2	-	-	-	7
Glendale	95,702	3	6	1	2	1	2	2	17
Richmond	99,545	2	3	-	3	2	-	1	11
Fla St P'burg	96,738	1	2	-	-	-	-	-	3
Ga Columbus	79,611	-	1	-	1	-	1	-	3
Ind Hammond	87,594	2	1	2	2	1	1	-	9
Iowa Sioux City	83,991	1	5	2	1	1	2	2	14
Kans Topeka	78,791	1	7	-	3	-	-	-	11
Me Portland	77,634	2	2	-	4	-	2	-	10
Mass Lawrence	80,536	-	1	-	1	-	-	-	2
Lowell	97,249	1	3	-	3	1	1	-	9
Lynn	99,738	1	1	-	3	-	-	1	6
Newton	81,994	2	3	-	6	-	2	2	15
Quincy	83,835	7	9	5	11	6	3	0	41
Mich Dearborn	94,994	-	4	-	1	-	-	-	5
Lansing	92,129	2	3	-	3	1	1	-	9
Saginaw	92,918	1	3	-	2	1	1	-	8
Miss Jackson	98,271	2	1	-	3	-	3	-	9
Mo St Joseph	78,588	2	4	-	4	3	-	3	16
N H Manchester	82,732	2	3	1	3	-	3	-	12
N J E Orange	79,340	2	2	-	2	-	-	-	6
N M Albu'que	96,815	5	1	-	1	-	2	-	9
N Y Binghamp'n	80,674	1	1	1	1	-	-	-	4
Sch'dy	91,785	1	2	-	-	3	-	2	8
N C Winst-Sal	87,811	1	3	1	1	-	1	-	7
Pa Wilkes-B'e	76,826	1	1	1	-	-	-	-	3
R I Pawtucket	81,436	1	2	1	1	-	-	-	5
Tex Waco	84,706	1	1	1	1	1	1	1	7
Va Portsm'th	80,039	1	1	-	1	-	1	-	4
Roanoke	91,921	2	4	-	7	-	2	1	16
W Va Huntington	86,353	-	1	-	-	-	-	-	1
Total		52	87	16	73	21	29	19	297

TABLE 27

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	3	3	-	2	-	-	5	13
Fresno	91,669	3	4	1	3	1	-	-	12
Glendale	95,702	4	7	2	2	1	2	2	20
Richmond	99,545	2	4	-	5	2	-	1	14
Fla St P'burg	96,738	1	2	-	1	-	-	-	4
Ga Columbus	79,611	-	1	-	1	-	1	-	3
Ind Hammond	87,594	2	1	2	4	2	1	-	12
Iowa Sioux City	83,991	1	6	3	2	1	2	2	17
Kans Topeka	78,791	1	7	-	4	-	-	-	12
Me Portland	77,634	2	3	-	5	-	2	-	12
Mass Lawrence	80,536	-	1	-	1	-	-	-	2
Lowell	97,249	1	3	-	3	1	1	-	9
Lynn	99,738	3	2	-	3	-	-	1	9
Newton	81,994	3	4	-	8	-	3	3	21
Quincy	83,835	9	11	6	13	7	4	-	50
Mich Dearborn	94,994	-	6	-	1	-	-	-	7
Lansing	92,129	2	4	-	2	1	1	-	10
Saginaw	92,918	1	4	-	2	1	1	-	9
Miss Jackson	98,271	2	1	-	3	-	3	-	9
Mo St Joseph	78,588	3	5	-	6	5	-	5	24
N H Manchester	82,732	3	3	2	5	-	4	-	17
N J E Orange	79,340	3	3	-	3	-	-	-	9
N M Albu'que	96,815	6	1	-	1	-	3	-	11
N Y Binghamp'n	80,674	3	1	1	1	-	-	-	6
Sch'dy	91,785	1	3	-	-	3	-	3	10
N C Winst-Sal	87,811	1	4	1	1	-	1	-	8
Pa Wilkes-B'e	76,826	1	1	1	-	1	-	-	4
R I P'wtucket	81,436	2	3	1	2	-	-	-	8
Tex Waco	84,706	1	2	1	1	1	1	2	9
Va Portsm'th	80,039	1	1	-	1	-	2	-	5
Roanoke	91,921	2	5	-	9	-	3	2	21
W Va Huntington	86,353	-	1	-	1	-	-	-	2
Total		67	107	21	96	27	35	26	379

TABLE 28

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 25 PERCENT
Group II Cities (Population 75, 000 to 100, 000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	-	-	-	-	-	-	1	1
Fresno	91,669	-	-	-	-	-	-	-	-
Glendale	95,702	-	-	-	-	-	-	-	-
Richmond	99,545	-	1	-	1	-	-	-	2
Fla St P'burg	96,738	-	-	-	-	-	-	-	-
Ga Columbus	79,611	-	-	-	-	-	-	-	-
Ind Hammond	87,594	-	-	-	-	-	-	-	-
Iowa Sioux City	83,991	-	-	-	-	-	-	1	1
Kans Topeka	78,791	-	3	2	1	-	-	-	6
Me Portland	77,634	-	-	-	-	-	-	-	-
Mass Lawrence	80,536	1	-	-	1	-	-	-	2
Lowell	97,249	1	-	1	-	-	-	-	2
Lynn	99,738	-	-	-	-	-	-	-	-
Newton	81,994	-	-	-	-	-	-	-	-
Quincy	83,835	2	2	3	4	2	-	-	13
Mich Dearborn	94,994	-	-	-	-	-	-	-	-
Lansing	92,129	-	-	3	-	-	-	-	3
Saginaw	92,918	-	-	-	-	-	-	-	-
Miss Jackson	98,271	-	1	1	1	-	-	-	3
Mo St Joseph	78,588	-	-	2	-	-	-	-	2
N H Manchester	82,732	-	-	-	-	-	-	-	-
N J E Orange	79,340	-	-	-	1	-	-	-	1
N M Albu'que	96,815	-	3	-	2	1	-	-	6
N Y Binghamp'n	80,674	-	-	-	-	-	-	-	-
Sch'dy	91,785	-	-	-	-	-	-	-	-
N C Winst-Sal	87,811	1	-	-	-	-	-	-	1
Pa Wilkes-B'e	76,826	-	-	-	-	-	-	-	-
R I Pawtucket	81,436	2	-	-	-	-	-	-	2
Tex Waco	84,706	-	-	-	-	-	-	-	-
Va Portsm'th	80,039	-	1	1	-	-	-	1	3
Roanoke	91,921	-	1	1	-	1	-	1	4
W Va Huntington	86,353	-	-	1	-	-	-	1	2
Total		7	12	15	10	5	0	5	54

TABLE 29

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 50 PERCENT
Group II Cities (Population 75,000 to 100,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	-	1	-	-	-	-	2	3
Fresno	91,669	-	-	-	-	1	-	-	1
Glendale	95,702	-	-	-	-	-	-	-	-
Richmond	99,545	-	1	-	1	-	-	-	2
Fla St P'burg	96,738	-	1	-	-	-	-	-	1
Ga Columbus	79,611	-	-	-	-	-	-	-	-
Ind Hammond	87,594	-	-	-	-	-	-	-	-
Iowa Sioux City	83,991	-	-	-	-	-	-	1	1
Kans Topeka	78,791	1	5	3	2	-	-	-	11
Me Portland	77,634	-	-	-	-	-	-	-	-
Mass Lawrence	80,536	1	-	-	1	-	-	-	2
Lowell	97,249	1	-	1	-	-	-	-	2
Lynn	99,738	-	-	-	-	-	-	-	-
Newton	81,994	-	-	-	-	-	-	-	-
Quincy	83,835	3	4	4	6	3	1	-	21
Mich Dearborn	94,994	-	-	-	-	-	-	-	-
Lansing	92,129	-	-	4	-	-	-	-	4
Saginaw	92,918	-	-	-	-	-	-	-	-
Miss Jackson	98,271	-	1	1	1	-	-	-	3
Mo St Joseph	78,588	-	-	3	-	-	-	-	3
N H Manchester	82,732	-	-	-	-	-	-	-	-
N J E Orange	79,340	-	-	-	-	2	-	-	2
N M Albu'que	96,815	-	4	-	3	1	-	-	8
N Y Binghamp'n	80,674	-	-	-	-	-	-	-	-
Sch'dy	91,785	-	-	-	-	-	-	-	-
N C Winst-Sal	87,811	1	-	-	-	-	-	-	1
Pa Wilkes-B'e	76,826	-	-	-	-	-	-	-	-
R I Pawtucket	81,436	3	-	-	-	1	-	-	4
Tex Waco	84,706	-	-	-	-	-	-	-	-
Va Portsm'th	80,039	1	1	1	2	1	-	-	6
Roanoke	91,921	-	1	1	-	1	-	-	3
W Va Huntington	86,353	-	-	1	-	-	-	1	2
Total		11	19	19	16	10	1	4	80

TABLE 30

NUMBER OF POSITIONS TO BE VACATED BY RETIREMENT DURING NEXT 10 YEARS
Group II Cities (Population 75,000 to 100,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Calif Burbank	88,043	-	-	-	-	-	-	2	2
Fresno	91,669	0	1	-	-	-	-	-	1
Glendale	95,702	-	-	-	-	-	-	-	0
Richmond	99,545	-	-	-	-	-	-	-	0
Fla St P'burg	96,738	-	-	-	-	-	-	-	-
Ga Columbus	79,611	-	-	-	-	-	-	-	-
Ind Hammond	87,594	-	-	-	-	-	-	-	-
Iowa Sioux City	83,991	0	0	0	0	0	0	2	2
Kans Topeka	78,791	-	-	-	-	-	-	-	-
Me Portland	77,634	-	2	-	-	-	-	-	2
Mass Lawrence	80,536	-	1	-	-	-	-	-	1
Lowell	97,249	-	-	-	-	-	-	-	0
Lynn	99,738	1	1	0	1	0	0	1	4
Newton	81,994	-	1	-	-	-	1	1	3
Quincy	83,835	4	3	2	6	2	0	0	17
Mich Dearborn	94,994	-	1	-	1	-	-	-	2
Lansing	92,129	-	-	-	-	-	-	-	0
Saginaw	92,918	0	2	0	1	0	0	0	3
Miss Jackson	98,271	0	0	0	2	0	0	-	2
Mo St Joseph	78,588	-	-	-	-	-	-	-	0
N H Manchester	82,732	1	1	-	-	-	-	-	2
N J E Orange	79,340	1	1	0	0	0	0	0	2
N M Albu'que	96,815	-	-	-	-	-	-	-	0
N Y Binghamp'n	80,674	-	-	-	1	-	-	-	1
Sch'dy	91,785	1	1	0	0	0	0	1	3
N C Winst-Sal	87,811	0	1	0	0	0	0	0	1
Pa Wilkes-B'e	76,826	1	1	1	-	-	-	-	3
R I Pawtucket	81,436	1	0	0	0	0	0	0	1
Tex Waco	84,706	-	-	-	-	-	-	-	0
Va Portsm th	80,039	0	1	0	0	0	1	0	2
Roanoke	91,921	-	1	-	1	-	1	-	3
W Va Huntington	86,353	-	-	-	-	-	-	-	0
Total		10	19	3	13	2	3	5	57

apparent regional pattern. The median value is 7.2. The range is about the same for the 50-percent and 100-percent expanded programs, but the median value decreases to 6.9 and 6.4. For the cities, the median values for the 1954 programs and for 25 percent and 50 percent expanded programs are 10.5, 13.5 and 14.5 respectively.

While these differences appear to be attributable principally to operating practices rather than program characteristics, they cannot be suggested as valid measures of operating efficiency without a much-more-detailed analysis. The differences among the states in classifying personnel as professional or subprofessional may well be responsible alone for a significant part of the wide variation. The ratios are presumed also to reflect variations among the highway departments in the effective use of their professional engineers and in methods and procedures used.

Returning to Figure 4, it is indicated that about 58,000 engineers will be required for an annual rate of capital outlay of $10 billion, which is the average annual rate of the program proposed by the Advisory Committee on a National Highway Program. As shown previously, there are presently employed in the highway departments 18,034 engineers. If there are added to the number of engineers employed in the highway departments, the numbers employed on highway work by cities, counties,

TABLE 31

NUMBER OF PROFESSIONAL ENGINEERS EMPLOYED IN 1954
Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Bridge Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	2	1	-	2	1	1	-	7
Ariz Phoenix	128,841	2	6	-	2	1	1	-	12
Ark Little Rock	102,213	1	1	1	-	-	-	-	3
Calif Berkeley	113,805	1	2	0	1	0	0	4	8
Long Beach	250,767	2	6	1	-	1	-	4	14
Oakland	284,575	5	10	-	3	1	3	12	34
Pasadena	104,577	2	2	-	1	-	-	2	7
Sacramento	137,572	3	2	1	2	-	-	-	8
San Diego	434,924	8	35	2	27	1	-	15	88
San Jose	102,148	2	3	-	2	1	-	2	10
Col Denver	415,786	1	3	3	16	2	1	4	30
Conn Hartford	177,397	1	1	-	1	1	-	4	8
New Haven	164,443	1	2	1	7	-	1	2	14
Waterbury	104,477	-	2	-	4	-	-	-	6
Dela Wilmington	110,356	2	1	-	1	-	-	2	6
Fla Jacksonv'le	204,517	1	1	1	-	-	-	4	7
Miami	249,276	1	2	1	1	-	1	1	7
Ga Savannah	119,638	2	1	0	0	0	1	1	5
Ill Peoria	111,856	3	3	-	-	-	-	-	6
Rockford	105,436	-	2	-	-	-	-	1	3
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	3	2	1	2	1	0	2	11
South Bend	115,911	1	-	-	-	1	-	-	2
Iowa Des Moines	177,965	2	4	1	2	1	-	-	10
Kans Kansas City	129,553	3	3	0	3	0	0	0	9
Wichita	168,279	1	3	1	5	1	1	1	13
Mass Fall River	111,963	1	3	-	-	-	-	-	4
Springfield	162,399	2	4	1	10	1	1	-	19
Worcester	203,486	1	13	1	3	0	0	0	18
Minn Duluth	104,511	0	3	0	2	0	0	4	9
Mo Kansas City	456,622	2	3	0	3	1	1	0	10
Nebr Omaha	251,117	2	2	-	6	-	-	-	10
N J Camden	124,555	-	3	-	3	-	-	-	6
Elizabeth	112,817	1	-	-	1	-	-	-	2
Trenton	128,009	2	1	-	1	-	-	-	4
N Y Albany	134,995	-	2	-	1	-	-	-	3
Rochester	332,488	1	1	1	1	1	0	0	5
Syracuse	230,583	-	2	3	4	-	-	-	9
Yonkers	152,798	-	-	-	2	-	-	-	2
N C Charlotte	134,042	1	1	1	1	-	1	-	5
Ohio Akron	274,605	½	4	1	2½	½	2	1½	12
Canton	116,912	-	-	-	1	-	-	-	1
Columbus	375,901	2	6	1	7	0	2	1	19
Dayton	243,872	7	3	6	5	-	1	-	22
Toledo	303,616	1	4	1	4	-	-	-	10
Okla Okla City	243,504	-	1	1	-	-	-	-	2
Ore Portland	373,628	3	2	5	3	1	1	17	32
Pa Erie	130,803	-	1	-	1	-	-	-	2
Reading	109,320	1	1	1	1	-	-	-	4
R I Providence	248,674	2	4	1	2	-	-	-	9
Tenn Memphis	396,000	2	4	2	10	1	1	-	20
Nashville	174,307	-	5	-	3	-	2	3	13
Knoxville	124,769	1	1	1	1	-	-	-	4
Tex Austin	132,459	1	1	1	1	-	1	-	5
Corpus Chr	108,287	4	1	-	1	-	-	-	6
Dallas	434,462	6	6	5	10	1	1	1	30
El Paso	130,485	0	2	0	1	0	0	-	3
Fort Worth	278,778	3	4	1	1	0	0	0	9
Va Norfolk	213,513	1	1	-	1	-	-	-	3
Richmond	230,310	2	4	3	5	-	5	3	22
Wash Seattle	467,591	14	8	12	24	2	4	-	64
Spokane	161,721	2	3	1	2	-	-	-	8
Tacoma	143,673	3	2	1	1	-	1	2	10
Total		118½	206	65	207½	21½	34	93½	746

TABLE 32

NUMBER OF ENGINEERING POSITIONS AFFECTED BY CONSULTANTS
Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	1	0	-	0	1	0	-	2
Ariz Phoenix	128,841	-	-	-	-	-	-	-	0
Ark Little Rock	102,213	-	-	-	-	-	-	-	0
Calif Berkeley	113,805	-	-	-	-	1	-	-	1
Long Beach	250,767	-	1	-	-	-	-	-	1
Oakland	384,575	-	-	-	-	-	-	3	3
Pasadena	104,577	-	-	-	-	-	-	-	0
Sacramento	137,572	0	3	1	2	0	0	0	6
San Diego	434,924	-	-	-	-	-	-	-	0
San Jose	102,148	-	-	1	-	-	-	-	1
Col Denver	415,786	-	-	-	-	-	-	-	0
Conn Hartford	177,397	-	-	-	-	-	-	-	-
New Haven	164,443	1	0	1	1	0	0	0	3
Waterbury	104,477	2	2	1	-	2	1	-	8
Dela Wilmington	110,356	-	-	-	-	-	-	-	0
Fla Jacksonv'le	204,517	2	1	4	-	-	-	5	12
Miami	249,276	1	-	-	-	1	-	-	1
Ga Savannah	119,638	0	8	0	9	1	0	3	21
Ill Peoria	111,856	-	-	1	-	1	-	-	2
Rockford	105,438	1	-	1	-	-	-	-	2
Ind Ft Wayne	133,607	-	-	-	-	-	-	-	-
Indianapolis	427,173	-	-	-	-	-	-	2	2
South Bend	115,911	-	1	-	-	-	-	-	1
Iowa Des Moines	177,965	-	2	4	-	-	-	-	6
Kans Kansas City	129,553	4	4	3	4	-	-	3	18
Wichita	168,279	0	2	1	1	0	0	0	4
Mass Fall River	111,963	1	3	-	-	-	2	-	6
Springfield	162,399	0	1	2	2	1	0	-	6
Worcester	203,486	4	0	0	0	0	0	0	4
Minn Duluth	104,511	-	-	-	-	-	-	-	0
Mo Kansas City	456,622	-	-	2	-	-	-	-	2
Nebr Omaha	251,117	-	1	1	1	1	-	-	4
N J Camden	124,555	-	-	-	-	-	-	-	0
Elizabeth	112,817	-	-	-	-	-	-	-	-
Trenton	128,009	1	-	-	-	2	-	-	3
N Y Albany	134,995	-	2	-	-	-	-	-	2
Rochester	332,488	0	0	0	0	0	0	0	0
Syracuse	230,583	-	-	-	-	1	-	-	1
Yonkers	152,798	-	-	1	-	-	-	-	1
N C Charlotte	134,042	-	-	2	1	-	-	-	3
Ohio Akron	274,605	2	4	2	0	0	0	2	10
Canton	116,912	-	-	-	-	-	-	-	0
Columbus	375,901	1	3	2	0	1	0	0	7
Dayton	243,872	3	4	4	-	4	-	-	15
Toledo	303,616	-	-	-	-	1	-	-	1
Okla Okla City	243,504	-	-	-	-	-	-	-	0
Ore Portland	373,628	-	-	-	-	-	-	3	3
Pa Erie	130,803	-	2	1	-	-	-	-	3
Reading	109,320	-	-	-	-	-	-	-	0
R I Providence	248,674	4	2	-	-	-	-	-	6
Tenn Memphis	396,000	3	0	0	0	-	0	-	3
Nashville	174,307	-	-	-	-	-	-	-	0
Knoxville	124,769	-	-	-	-	-	-	-	0
Tex Austin	132,459	-	-	1	-	-	-	-	1
Corpus Chri	108,287	-	-	-	-	2	-	-	2
Dallas	434,462	-	13	12	4	4	-	-	33
El Paso	130,485	0	0	0	0	0	0	-	0
Forth Worth	278,778	1	2	1	0	0	0	0	4
Va Norfolk	213,513	1	-	-	-	-	-	-	1
Richmond	230,310	-	-	-	-	-	-	-	0
Wash Seattle	467,591	-	-	-	-	-	-	-	0
Spokane	161,721	-	1	-	1	-	-	-	2
Tacoma	143,673	-	-	2	-	-	-	-	2
Total		31	63	51	26	24	3	21	219

TABLE 33

NUMBER OF PROFESSIONAL ENGINEERS DESIRED IN ADDITION TO (1) AND (2)
Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	1	1	-	2	1	1	-	6
Ariz Phoenix	128,841	-	-	-	-	-	-	-	0
Ark Little Rock	102,213	-	-	-	-	-	1	-	1
Calif Berkeley	113,805	-	-	-	-	-	-	-	0
Long Beach	250,767	-	2	-	-	-	-	-	2
Oakland	384,575	2	3	-	1	2	1	3	12
Pasadena	104,577	2	3	-	1	-	-	1	7
Sacramento	137,572	-	-	-	-	-	-	-	0
San Diego	434,924	2	4	1	4	-	-	-	11
San Jose	102,148	3	4	-	3	1	-	2	13
Col Denver	415,786	1	4	4	17	2	1	4	33
Conn Hartford	177,397	-	1	1	1	-	-	-	3
New Haven	164,44..	-	-	-	4	-	-	-	4
Waterbury	104 477	2	4	2	8	2	-	-	18
Dela Wilmington	110,356	-	-	-	-	-	-	-	0
Fla Jacksonv'le	204,517	1	1	1	-	-	-	5	8
Miami	249,276	1	-	-	1	1	2	-	5
Ga Savannah	119,638	0	0	1	1	1	2	1	6
Ill Peoria	111,856	1	1	-	-	1	-	1	4
Rockford	105,438	1	1	1	1	1	1	-	6
Ind Ft Wayne	133,607	-	-	-	-	-	-	-	-
Indianapolis	427,173	2	1	2	2	1	0	2	10
South Bend	115,911	-	1	-	-	-	-	-	1
Iowa Des Moines	177,965	1	-	-	1	1	-	-	3
Kans Kansas City	129,553	1	2	1	2	0	0	3	9
Wichita	168,279	1	1	1	2	0	0	0	5
Mass Fall River	111,963	2	5	-	-	-	4	-	11
Springfield	162 399	0	2	1	2	0	1	-	6
Worcester	203,486	2	0	0	0	1	0	0	3
Minn Duluth	104,511	1	2	1	1	1	1	1	8
Mo Kansas City	456,622	2	-	-	-	-	-	-	2
Nebr Omaha	251,117	1	1	1	1	-	1	-	5
N J Camden	124,555	-	-	-	-	-	-	-	0
Elizabeth	112,817	1	-	-	1	-	-	-	2
Trenton	128,009	1	2	-	2	-	2	-	7
N Y Albany	134,995	-	2	-	2	-	-	1	5
Rochester	332,488	1	-	-	-	-	-	-	1
Syracuse	230,583	-	2	1	2	1	-	-	6
Yonkers	152,798	-	-	-	1	-	-	-	1
N C Charlotte	134,042	-	-	-	-	-	-	-	0
Ohio Akron	274,605	3	3	2	2	1	4	1	16
Canton	116,912	-	1	-	-	-	-	-	1
Columbus	375,901	1	4	1	4	1	1	-	12
Day on	243,872	2	3	2	2	-	-	-	9
Toledo	303,616	-	-	-	-	-	-	-	0
Okla Okla City	243,504	-	-	-	-	-	-	-	0
Ore Portland	373,628	-	1	-	2	-	1	-	4
Pa Erie	130,803	-	3	1	1	1	-	-	6
Reading	109,320	-	-	-	-	-	-	-	0
R I Providence	248,674	2	2	1	2	-	-	-	7
Tenn Memphis	396,000	2	2	1	-	-	-	-	5
Nashville	174,307	-	-	-	-	-	-	-	0
Knoxville	124,769	-	-	-	-	-	-	-	0
Tex Austin	132,459	-	1	-	-	-	1	-	2
Corpus Chri	108,287	-	1	-	1	-	-	-	2
Dallas	434,462	3	5	5	7	3	-	-	23
El Paso	130,485	0	0	0	0	0	0	-	0
Fort Worth	278,778	1	1	-	2	-	-	-	4
Va Norfolk	213,513	-	-	-	-	-	-	-	0
Richmond	230,310	1	2	-	1	-	-	2	6
Wash Seattle	467,591	-	-	-	-	-	-	-	0
Spokane	161,721	-	1	1	0	-	-	-	2
Tacoma	143,673	1	0	-	1	-	-	-	4
Total		49	82	33	88	23	25	27	327

TABLE 34

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	2	1	-	2	1	1	-	7
Ariz Phoenix	128,841	2	7	-	2	1	1	-	13
Ark Little Rock	102,213	1	1	1	-	-	-	-	3
Calif Berkeley	113,805	1	2	-	1	-	-	4	8
Long Beach	250,767	3	7	1	-	1	-	4	16
Oakland	384,575	7	15	-	5	4	5	22	58
Pasadena	104,577	2	5	-	2	-	-	2	11
Sacramento	137 572	4	4	2	4	-	-	-	14
San Diego	434,924	10	43	3	31	1	-	15	103
San Jose	102,148	3	4	-	3	1	-	2	13
Col Denver	415,786	1	4	4	17	2	1	4	33
Conn Hartford	177,397	2	2	2	2	1	-	4	13
New Haven	164,443	1	2	1	7	-	1	2	14
Waterbury	104,477	2	4	2	6	1	-	-	15
Dela Wilmington	110,356	2	1	-	1	-	-	2	6
Fla Jacksonv'le	204,517	1	2	2	-	-	-	4	9
Miami	249 276	2	2	1	2	-	2	1	10
Ga Savannah	119,638	3	1	1	1	-	3	2	11
Ill Peoria	111,856	5	5	-	-	-	1	-	11
Rockford	105,438	1	2	1	1	1	1	1	8
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	4	2	3	3	2	-	4	18
South Bend	115,911	1	1	-	1	-	-	-	3
Iowa Des Moines	177,965	3	5	3	3	1	-	-	15
Kans Kansas City	129,553	2	4	1	4	-	-	6	17
Wichita	168,279	2	4	2	6	2	2	1	19
Mass Fall River	111,963	2	3	-	-	-	-	-	5
Springfield	162,399	2	6	1	10	1	1	-	21
Worcester	203,486	8	15	1	3	-	1	-	28
Minn Duluth	104,511	-	4	-	2	-	-	5	11
Mo Kansas City	456,622	4	4	1	4	1	1	-	15
Nebr Omaha	251,117	3	2	3	3	2	-	4	17
N J Camden	124,555	-	4	-	4	-	-	-	8
Elizabeth	112,817	2	-	-	2	-	-	-	4
Trenton	128,009	3	2	-	2	-	1	-	8
N Y Albany	134,995	-	4	-	4	-	-	1	9
Rochester	332,488	1	1	1	1	1	-	-	5
Syracuse	230,583	-	5	4	7	2	-	-	18
Yonkers	152,798	-	-	-	2	-	-	-	2
N C Charlotte	134,042	1	1	1	1	-	1	-	5
Ohio Akron	274,605	1	4	1	3	1	2	-	12
Canton	116,912	-	1	-	1	-	-	-	2
Columbus	372,901	1	8	-	6	-	3	1	19
Dayton	243,872	11	19	9	9	-	1	-	49
Toledo	303,616	1	5	1	5	-	-	-	12
Okla Okla City	243,504	-	2	1	-	-	-	-	3
Ore Portland	373,628	3	3	7	4	2	1	-	20
Pa Erie	130,803	-	1	-	-	1	-	-	2
Reading	109,320	1	1	1	1	-	1	-	5
R L Providence	248,674	3	5	2	3	-	-	-	13
Tenn Memphis	396,000	3	6	3	12	1	1	-	26
Nashville	174,307	-	8	4	8	3	4	-	27
Knoxville	124,769	2	1	2	1	1	-	-	7
Tex Austin	132,459	2	3	1	3	-	2	-	11
Corpus Chri	108,287	5	2	-	2	-	1	-	10
Dallas	434,462	15	15	13	19	4	1	2	69
El Paso	130,485	-	2	-	1	-	-	-	3
Fort Worth	278,778	4	4	1	4	1	-	-	14
Va Norfolk	213,513	-	1	-	1	-	1	-	3
Richmond	230,310	4	6	4	6	-	5	5	30
Wash Seattle	467,591	14	8	12	24	2	4	-	64
Spokane	161,721	2	8	4	5	-	-	-	19
Tacoma	143,673	4	4	1	2	-	-	1	12
Total		169	300	109	289	42	51	100	1040

TABLE 35

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 50 PERCENT

Group III Cities (Population 100,000 to 500,000)

State and City		Plan & Traffic	Street Design	Bridge Design	Mater & Constr	Tests	Maint	Other	Total
Ala Montg'ry	106,525	2	2	-	4	1	1	-	10
Ariz Phoenix	128,841	2	8	-	2	1	1	-	14
Ark Little Rock	102,213	1	1	1	-	-	1	-	4
Calif Berkeley	113,805	1	2	-	2	-	-	4	9
Long Beach	250,767	4	10	2	-	2	-	6	24
Oakland	384,575	10	19	-	6	5	6	27	73
Pasadena	104,577	4	5	-	3	-	-	3	15
Sacramento	137,572	5	6	3	6	-	-	-	20
San Diego	434,924	11	51	3	37	1	-	18	121
San Jose	102,148	3	5	-	3	1	-	3	15
Col Denver	415,786	2	5	5	20	3	1	4	40
Conn Hartford	177,397	2	2	2	2	2	-	4	14
New Haven	164,443	1	2	1	7	-	1	2	14
Waterbury	104,477	2	4	2	6	1	-	2	17
Dela Wilmington	110,356	2	2	-	2	-	-	2	8
Fla Jacksonv'le	204,517	2	2	3	-	-	-	4	11
Miami	249,276	2	3	1	2	-	2	2	12
Ga Savannah	119,638	3	1	1	2	-	4	3	14
Ill Peoria	111,856	5	6	-	-	-	1	-	12
Rockford	105,438	1	2	1	2	1	1	1	9
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	5	3	4	4	3	-	5	24
South Bend	115,911	1	1	-	1	-	-	-	3
Iowa Des Moines	177,965	4	6	4	4	2	-	-	20
Kans Kansas City	129,553	3	6	1	6	-	-	9	25
Wichita	168,279	2	5	2	7	2	3	1	22
Mass Fall River	111,963	3	3	-	-	-	-	-	6
Springfield	162,399	3	6	1	12	2	1	-	25
Worcester	203,486	10	16	1	5	1	1	-	34
Minn Duluth	104,511	1	4	-	3	1	-	4	13
Mo Kansas City	456,622	6	5	3	5	1	1	1	22
Nebr Omaha	251,117	4	2	3	3	2	-	4	18
N J Camden	124,555	-	4	-	4	-	-	-	8
Elizabeth	112,817	2	1	-	2	-	-	-	5
Trenton	128,009	4	2	-	3	-	2	-	11
N Y Albany	134,995	-	5	-	5	-	-	1	11
Rochester	332,488	1	1	1	1	1	-	-	5
Syracuse	230,583	-	6	5	7	1	-	-	19
Yonkers	152,798	-	-	-	3	-	-	-	3
N C Charlotte	134,042	2	1	1	2	-	1	1	7
Ohio Akron	274,605	4	6	2	4	2	2	2	22
Canton	116,912	-	1	-	1	-	-	-	2
Columbus	375 901	1	9	1	8	-	3	1	23
Dayton	243,872	12	22	10	11	-	2	-	57
Toledo	303,616	1	6	1	6	-	-	-	14
Okla Okla City	243,504	-	2	1	-	-	-	-	3
Ore Portland	373,628	4	4	10	6	2	2	-	28
Pa Erie	130,803	-	2	-	1	1	-	-	4
Reading	109,320	1	1	1	1	-	1	1	6
R I Providence	248,674	4	6	3	4	-	-	-	17
Tenn Memphis	396,000	3	8	4	14	1	1	-	31
Nashville	174,307	-	12	6	10	5	6	-	39
Knoxville	124,769	2	2	3	2	1	-	-	10
Tex Austin	132,459	2	5	2	4	-	3	-	16
Corpus Chri	108,287	7	3	-	3	-	2	-	15
Dallas	434,462	18	16	13	22	5	2	2	78
El Paso	130,485	2	3	1	1	-	-	-	7
Fort Worth	278,778	5	5	1	5	1	-	-	17
Va Norfolk	213,513	1	1	-	1	-	1	-	4
Richmond	230,310	5	6	5	6	-	5	6	33
Wash Seattle	467,591	16	9	13	27	2	4	-	71
Spokane	161,721	3	8	4	6	1	1	-	23
Tacoma	143,673	5	4	2	3	1	2	2	19
Total		212	358	134	329	56	65	124	1278

TABLE 36

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 25 PERCENT

Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Mater & Constr	Tests	Maint	Other	Total
Ala Montg'ry	106,525	2	3	-	4	1	2	-	12
Ariz Phoenix	128,841	2	7	-	2	1	1	-	13
Ark Little Rock	102,213	1	1	1	-	-	-	-	3
Calif Berkeley	113,805	1	2	-	2	-	-	4	9
Long Beach	250,767	3	7	1	1	1	-	4	17
Oakland	384,575	12	25	-	8	5	8	34	92
Pasadena	104,577	4	5	-	3	-	-	3	15
Sacramento	137,572	5	5	3	5	-	-	-	18
San Diego	434,924	11	45	3	34	2	-	18	113
San Jose	102,148	3	4	-	3	1	-	2	13
Col Denver	415,786	1	4	4	18	3	1	4	35
Conn Hartford	177,397	2	3	2	3	2	-	4	16
New Haven	164,443	1	2	1	11	-	1	2	18
Waterbury	104,477	2	4	2	6	1	-	-	15
Dela Wilmington	110,356	2	1	-	1	-	-	2	6
Fla Jacksonv'le	204,517	2	2	3	-	-	-	4	11
Miami	249,276	2	2	1	2	-	2	2	11
Ga Savannah	119,638	3	1	1	1	-	4	2	12
Ill Peoria	111,856	5	5	-	-	1	-	1	12
Rockford	105,438	1	4	1	2	1	1	1	11
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	4	2	4	4	2	-	4	20
South Bend	115,911	1	1	-	1	-	-	-	3
Iowa Des Moines	177,965	4	6	4	4	1	-	-	19
Kans Kansas City	129,553	2	4	1	4	-	-	6	17
Wichita	168,279	3	5	3	8	2	2	1	24
Mass Fall River	111 963	3	5	-	-	-	4	-	12
Springfield	162,399	2	6	1	10	1	2	-	22
Worcester	203 486	8	17	2	5	1	1	-	34
Minn Duluth	104,511	-	4	-	2	-	-	5	11
Mo Kansas City	456,622	4	4	1	4	1	1	-	15
Nebr Omaha	251,117	3	3	3	5	2	-	5	21
N J Camden	124,555	1	4	-	4	-	-	-	9
Elizabeth	112,817	2	-	-	2	-	-	-	4
Trenton	128,009	4	2	-	3	-	2	-	11
N Y Albany	134,995	-	4	-	4	-	-	1	9
Rochester	332,488	2	1	1	1	1	-	-	6
Syracuse	230 583	-	5	5	8	1	-	-	19
Yonkers	152,798	-	-	-	3	-	-	-	3
N C Charlotte	134,042	2	1	1	2	-	1	-	7
Ohio Akron	274,605	4	6	2	4	2	4	2	24
Canton	116,912	-	1	-	1	-	-	-	2
Columbus	375,901	2	9	1	11	-	3	2	28
Dayton	243,872	14	24	12	11	1	1	-	63
Toledo	303,616	1	5	1	5	-	-	-	12
Okla Okla City	243,504	-	2	1	-	-	-	-	3
Ore Portland	373,628	4	4	10	6	2	2	-	28
Pa Erie	130,803	-	3	1	1	1	-	-	6
Reading	109,320	1	1	1	1	-	1	-	5
R I Providence	248,674	5	7	2	6	-	-	-	20
Tenn Memphis	396,000	3	6	3	12	1	1	-	26
Nashville	174,307	-	10	6	10	5	5	-	36
Knoxville	124,769	3	2	3	2	2	-	-	12
Tex Austin	132,459	2	3	1	3	1	2	-	12
Corpus Chri	108,287	6	4	-	4	-	3	-	17
Dallas	434,462	18	18	15	20	6	1	3	81
El Paso	130,485	-	2	-	1	-	-	-	3
Fort Worth	278,778	5	5	1	5	1	-	-	17
Va Norfolk	213,513	-	1	-	1	-	1	-	3
Richmond	230,310	5	6	4	6	-	6	6	33
Wash Seattle	467,591	18	10	14	30	3	5	-	80
Spokane	161 721	2	8	4	5	-	-	-	19
Tacoma	143,673	4	4	1	3	-	1	2	15
Total		207	349	132	328	56	69	124	1265

TABLE 37

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 50 PERCENT

Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Mater & Constr	Tests	Maint	Other	Total
Ala Montg'ry	106,525	2	4	-	5	2	2	-	15
Ariz Phoenix	128,841	2	8	-	2	1	1	-	14
Ark Little Rock	102,213	1	1	1	-	-	1	-	4
Calif Berkeley	113,805	2	2	-	2	-	-	4	10
Long Beach	250,767	4	10	2	1	2	-	6	25
Oakland	384,575	15	29	-	9	6	9	39	107
Pasadena	104,577	5	6	-	4	-	-	4	19
Sacramento	137,572	7	8	5	8	-	-	-	28
San Diego	434,924	13	55	4	41	3	-	21	137
San Jose	102,148	3	5	-	3	1	-	3	15
Col Denver	415,786	2	6	6	22	4	1	5	46
Conn Hartford	117,397	2	3	3	3	2	-	5	18
New Haven	164,443	1	2	1	11	-	1	2	18
Waterbury	104,477	2	6	2	8	2	-	3	23
Dela Wilmington	110,356	2	2	-	2	-	-	2	8
Fla Jacksonv'le	204,517	2	2	4	-	-	-	5	13
Miami	249,276	3	3	2	2	-	2	2	14
Ga Savannah	119,638	3	1	1	2	-	2	3	15
Ill Peoria	111,856	5	6	-	-	1	-	1	13
Rockford	105,438	1	4	2	3	2	2	1	15
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	5	3	5	5	3	-	5	26
South Bend	115,911	1	1	-	1	-	-	-	3
Iowa Des Moines	177,965	5	8	5	5	1	-	-	24
Kans Kansas City	129,553	3	6	1	6	-	-	9	25
Wichita	168,279	3	5	3	8	2	3	2	26
Mass Fall River	111,963	3	2	-	-	-	4	-	9
Springfield	162,399	3	6	1	12	2	2	-	26
Worcester	203,486	10	18	2	7	1	2	-	40
Minn Duluth	104,511	2	3	1	2	2	1	3	14
Mo Kansas City	456,622	6	5	3	5	1	1	1	22
Nebr Omaha	251,117	5	4	3	5	3	-	5	25
N J Camden	124,55	1	4	-	4	-	-	-	9
Elizabeth	112,817	2	1	-	3	-	-	-	6
Trenton	128,009	5	3	-	6	-	3	-	17
N Y Albany	134,995	-	5	-	5	-	-	1	11
Rochester	332,488	2	2	2	1	1	-	-	8
Syracuse	230,583	-	6	6	9	1	-	-	22
Yonkers	152,798	-	-	-	4	-	-	-	4
N C Charlotte	134,042	2	2	2	2	-	1	-	9
Ohio Akron	274,605	4	7	3	5	3	6	2	30
Canton	116,912	-	1	-	1	-	-	-	2
Columbus	375,901	1	7	-	9	-	4	1	22
Dayton	243,872	18	32	16	15	2	3	-	86
Toledo	303,616	1	6	1	6	-	-	-	14
Okla Okla City	243,504	-	2	1	-	-	-	-	3
Ore Portland	373,628	6	6	15	9	3	3	-	42
Pa Erie	130,803	-	3	1	1	1	-	-	6
Reading	109,320	1	1	1	1	-	1	1	6
R I Providence	248,674	4	8	4	8	-	-	-	24
Tenn Memphis	396,000	3	10	4	16	1	1	-	35
Nashville	174,307	-	15	8	12	8	8	-	51
Knoxville	124,769	3	3	4	3	2	-	-	15
Tex Austin	132,459	2	2	1	4	1	3	-	13
Corpus Chri	108,287	8	5	-	5	-	4	-	22
Dallas	434,462	20	21	15	24	7	2	3	92
El Paso	130,485	2	2	1	2	-	-	-	7
Fort Worth	278,778	6	6	1	6	1	-	-	20
Va Norfolk	213,513	1	1	-	1	-	1	-	4
Richmond	230,310	5	6	5	8	-	6	6	36
Wash Seattle	467 591	21	12	17	36	3	5	-	94
Spokane	161,721	3	8	4	6	1	1	-	23
Tacoma	143,673	5	5	2	4	1	2	3	22
Total		249	418	171	400	77	91	148	1554

TABLE 38

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 25 PERCENT

Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	-	-	-	-	1	-	-	1
Ariz Phoenix	128,841	-	-	-	-	-	-	-	-
Ark Little Rock	102,213	-	-	-	-	-	-	-	-
Calif Berkeley	113,805	-	-	-	-	1	-	-	1
Long Beach	250,767	-	1	1	-	-	-	-	2
Oakland	384,575	-	-	-	-	-	-	-	-
Pasadena	104,577	-	-	2	-	2	-	-	4
Sacramento	137,572	-	-	-	-	1	-	-	1
San Diego	434,924	-	-	-	-	-	-	-	-
San Jose	102,148	-	-	1	-	-	-	-	1
Col Denver	415,786	-	-	-	-	-	-	-	-
Conn Hartford	177,397	-	-	-	-	-	-	-	-
New Haven	164,443	1	-	1	1	-	-	-	3
Waterbury	104,477	1	2	-	2	1	-	-	6
Dela Wilmington	110,356	-	-	-	-	-	-	-	-
Fla Jacksonv'le	204,517	3	2	3	-	-	-	6	14
Miami	249,276	-	-	-	-	1	-	-	1
Ga Savannah	119,638	-	8	-	9	1	-	3	21
Ill Peoria	111,856	-	-	-	-	-	-	-	-
Rockford	105,438	-	1	1	-	-	-	-	2
Ind Ft Wayne	133,607	-	-	-	-	-	-	-	-
Indianapolis	427,173	-	-	-	-	-	-	-	-
South Bend	115,911	-	-	-	-	-	-	-	-
Iowa Des Moines	177,965	3	3	5	3	-	-	-	14
Kans Kansas City	129,553	-	-	-	-	-	-	-	-
Wichita	168,279	-	-	-	-	-	-	-	-
Mass Fall River	111,963	-	3	-	2	-	1	-	6
Springfield	162,399	-	-	1	2	-	-	-	3
Worcester	203,486	1	1	-	-	1	-	-	3
Minn Duluth	104,511	-	-	-	1	-	-	-	1
Mo Kansas City	456,622	-	-	2	-	-	-	-	2
Nebr Omaha	251,117	-	-	1	-	1	-	-	2
N J Camden	124,555	-	-	-	-	-	-	-	-
Elizabeth	112,817	-	-	-	-	-	-	-	-
Trenton	128,009	-	-	-	1	-	-	-	1
N Y Albany	134,995	-	1	-	-	-	-	-	1
Rochester	332,488	-	-	-	-	-	-	-	-
Syracuse	230,583	-	-	1	-	1	-	-	2
Yonkers	152,798	-	-	-	-	-	-	-	-
N C Charlotte	134,042	-	-	1	-	1	-	-	2
Ohio Akron	274,605	2	4	2	-	-	-	2	10
Canton	116,912	-	-	-	-	-	-	-	-
Columbus	375,901	2	4	3	4	2	-	-	15
Dayton	243,872	4	6	6	-	5	-	-	21
Toledo	303,616	-	-	-	-	1	-	-	1
Okla Okla City	243,504	-	-	-	-	-	-	-	-
Ore Portland	373,628	-	-	-	-	-	-	-	-
Pa Erie	130,803	-	2	1	1	-	-	-	4
Reading	109,320	-	-	-	-	-	-	-	-
R I Providence	248,674	2	2	1	1	-	-	-	6
Tenn Memphis	396,000	-	-	-	-	-	-	-	-
Nashville	174,307	-	-	-	-	-	-	-	-
Knoxville	124,769	-	-	-	-	-	-	-	-
Tex Austin	132,459	-	-	-	-	1	-	-	1
Corpus Chri	108,287	-	-	-	-	4	-	-	4
Dallas	434,462	-	12	12	5	6	-	-	35
El Paso	130,485	-	-	-	-	-	-	-	-
Fort Worth	278,778	1	2	1	-	-	-	-	4
Va Norfolk	213,513	-	-	-	-	-	-	-	-
Richmond	230,310	-	-	-	-	-	-	-	-
Wash Seattle	467,591	-	-	-	-	-	-	-	-
Spokane	161,721	-	1	1	-	-	-	-	2
Tacoma	143,673	-	-	-	-	-	-	-	-
Total		20	56	47	32	31	1	11	197

TABLE 39

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 50 PERCENT

Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	1	-	1	-	1	1	-	4
Ariz Phoenix	128,841	-	-	-	-	-	-	-	-
Ark Little Rock	102,213	-	-	-	-	-	1	-	1
Calif Berkeley	113,805	-	-	-	-	1	-	-	1
Long Beach	250,767	-	2	1	-	-	-	-	3
Oakland	384,575	-	-	-	-	-	-	-	-
Pasadena	104,577	-	-	3	-	3	-	-	6
Sacramento	137,572	-	-	-	-	2	-	-	2
San Diego	434,924	-	-	-	-	-	-	-	-
San Jose	102,148	-	-	1	-	-	-	-	1
Col Denver	415,786	-	-	-	-	-	-	-	-
Conn Hartford	177,397	-	-	-	-	-	-	-	-
New Haven	164,443	1	-	1	1	-	-	-	3
Waterbury	104,477	1	2	-	2	1	-	-	6
Dela Wilmington	110,356	-	-	-	-	-	-	-	-
Fla Jacksonv'le	204,517	5	4	6	-	-	-	9	24
Miami	249,276	-	-	-	-	1	-	-	1
Ga Savannah	119,638	-	9	-	10	1	-	3	23
Ill Peoria	111,856	-	-	-	-	-	-	-	-
Rockford	105,438	1	2	2	-	-	-	1	6
Ind Ft Wayne	133,607	-	-	-	-	-	-	-	-
Indianapolis	427,173	-	-	-	-	-	-	-	-
South Bend	115,911	1	-	-	-	1	-	-	2
Iowa Des Moines	177,965	5	6	7	5	-	-	-	23
Kans Kansas City	129,553	-	-	-	-	-	-	-	-
Wichita	168,279	-	-	-	-	-	-	-	-
Mass Fall River	111,963	-	6	-	4	-	2	-	12
Springfield	162,399	-	1	1	2	-	-	-	4
Worcester	203,486	1	2	-	-	1	-	-	4
Minn Duluth	104,511	-	-	1	-	-	-	-	1
Mo Kansas City	456,622	-	-	2	-	-	-	-	2
Nebr Omaha	251,117	-	-	2	-	2	-	-	4
N J Camden	124,555	-	-	-	-	-	-	-	-
Elizabeth	112,817	-	-	-	-	-	-	-	-
Trenton	128,009	-	-	-	1	-	-	-	1
N Y Albany	134,995	-	1	-	-	-	-	-	1
Rochester	332,488	-	-	-	-	-	-	-	-
Syracuse	230,583	-	-	2	-	1	-	-	3
Yonkers	152,798	-	-	1	-	-	-	-	1
N C Charlotte	134,042	-	-	2	-	1	-	-	3
Ohio Akron	274,605	3	4	2	-	-	-	2	11
Canton	116,912	-	-	-	-	-	-	-	-
Columbus	375,901	3	6	4	6	2	-	1	22
Dayton	243,872	6	8	8	-	6	-	-	28
Toledo	303,616	-	-	-	-	1	-	-	1
Okla Okla City	243,504	-	-	-	-	-	-	-	-
Ore Portland	373,628	-	-	-	-	-	-	-	-
Pa Erie	130,803	-	3	1	1	-	-	-	5
Reading	109,320	-	-	-	-	-	-	-	-
R I Providence	248,674	4	4	2	2	-	-	-	12
Tenn Memphis	396,000	-	-	-	-	-	-	-	-
Nashville	174,307	-	-	-	-	-	-	-	-
Knoxville	124,769	-	-	-	-	-	-	-	-
Tex Austin	132,459	1	-	-	-	1	-	-	2
Corpus Chri	108,287	-	-	-	-	6	-	-	6
Dallas	434,462	-	15	15	6	7	-	-	43
El Paso	130,485	-	-	-	-	-	-	-	-
Fort Worth	278,778	1	3	1	-	-	-	-	5
Va Norfolk	213,513	-	-	-	-	-	-	-	-
Richmond	230,310	-	-	-	-	-	-	-	-
Wash Seattle	467,591	5	3	4	9	1	1	-	23
Spokane	161,721	-	2	2	1	-	-	-	5
Tacoma	143,673	-	-	2	-	1	-	-	3
Total		39	83	74	50	41	5	16	308

TABLE 40

NUMBER OF POSITIONS TO BE VACATED BY RETIREMENT DURING NEXT 10 YEARS

Group III Cities (Population 100,000 to 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Ala Montg'ry	106,525	1	1	-	-	-	-	-	2
Ariz Phoenix	128,841	-	3	-	-	-	-	-	3
Ark Little Rock	102,213	-	-	-	-	-	-	-	0
Calif Berkeley	113,805	-	-	-	-	-	-	-	0
Long Beach	250,767	-	2	-	-	1	-	1	4
Oakland	384,575	-	1	-	-	-	-	3	4
Pasadena	104,577	2	2	-	1	-	-	2	7
Sacramento	137,572	-	1	-	-	-	-	-	1
San Diego	434,924	1	3	1	7	-	-	2	14
San Jose	102,148	1	1	1	-	-	-	1	4
Col Denver	415,786	0	4	2	4	1	1	2	14
Conn Hartford	177,397	-	-	1	-	-	-	4	5
New Haven	164,443	1	2	1	3	0	0	1	8
Waterbury	104,477	-	2	-	4	-	-	-	6
Dela Wilmington	110,356	1	1	-	-	-	-	-	2
Fla Jacksonv'le	204,517	0	0	1	-	-	-	4	5
Miami	249,276	1	-	1	-	-	1	1	4
Ga Savannah	119,638	1	0	0	0	0	0	0	1
Ill Peoria	111,856	-	1	-	-	-	-	-	1
Rockford	105,438	-	-	-	-	-	-	-	-
Ind Ft Wayne	133,607	-	2	-	-	-	-	-	2
Indianapolis	427,173	2	3	2	2	1	0	3	13
South Bend	115,911	1	-	-	-	-	-	-	1
Iowa Des Moines	117,965	1	3	1	-	1	-	-	6
Kans Kansas City	129,553	1	1	-	-	-	-	2	4
Wichita	168,279	0	1	0	1	0	0	0	2
Mass Fall River	111,963	1	4	-	2	-	1	-	8
Springfield	162,399	1	3	-	2	-	1	-	7
Worcester	203,486	0	2	1	0	0	0	0	3
Minn Duluth	104,511	-	-	-	-	-	-	4	4
Mo Kansas City	456,622	0	1	0	1	0	0	0	2
Nebr Omaha	251,117	1	1	-	1	1	-	-	4
N J. Camden	124,555	-	3	-	-	-	-	-	3
Elizabeth	112,817	1	-	-	-	-	-	-	1
Trenton	128,009	-	-	-	-	-	-	-	0
N Y Albany	134,995	-	2	-	1	-	-	-	3
Rochester	332,488	1	1	-	1	-	-	-	3
Syracuse	230,583	-	1	2	3	-	-	-	6
Yonkers	152,798	-	-	-	3	-	-	-	3
N C Charlotte	134,042	-	1	-	-	-	-	-	1
Ohio Akron	274,605	1	3	1	1	1	2	1	10
Canton	116,912	-	-	-	-	-	-	-	0
Columbus	375,901	1	2	1	3	-	1	-	8
Dayton	243,872	-	1	-	1	-	1	-	3
Toledo	303,616	-	1	-	1	-	-	-	2
Okla Okla City	243,504	-	-	-	-	-	-	-	0
Ore Portland	373,628	1	1	-	2	1	1	8	14
Pa Erie	130,803	-	1	-	1	-	-	-	2
Reading	109,320	1	1	-	1	-	1	-	4
R I Providence	248,674	1	2	1	1	-	-	-	5
Tenn Memphis	396,000	-	1	-	4	-	-	-	5
Nashville	174,307	-	1	-	2	1	1	-	5
Knoxville	124,769	1	-	1	1	-	-	-	3
Tex Austin	132,459	1	1	-	-	-	-	-	2
Corpus Chri.	108,287	-	-	-	-	-	-	-	0
Dallas	434,462	2	1	1	2	-	-	-	6
El Paso	130,485	0	0	0	0	0	0	0	0
Fort Worth	278,778	0	1	0	0	0	0	0	1
Va Norfolk	213,513	-	-	-	-	-	-	-	0
Richmond	230,310	-	-	-	-	-	-	-	0
Wash Seattle	467,591	4	2	3	6	1	1	-	17
Spokane	161,721	-	1	-	1	-	-	-	2
Tacoma	143,673	-	1	-	-	-	-	1	2
Total		32	74	22	63	9	12	40	252

TABLE 41

NUMBER OF PROFESSIONAL ENGINEERS EMPLOYED IN 1954
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Los Ang's	2,104,663	42	116	20	8	2	-	-	188
San Fran	775,357	7	17	1	4	1	5	10	45
Ill. Chicago	3,620,962	20	20	60	50	5	-	-	155
La. New Orlea	570,445	5	6	1	4	-	4	3	23
Mass Boston	801,444	8	9	6	36	3	3	1	66
Mich. Detroit	1,849,568	30	15	4	9	1	2	8	69
Minn. Minne'lis	521,718	4	3	2	4	2	3	-	18
Mo St Louis	856,796	5	3	3	8	3	5	-	27
N Y Brooklyn	2,738,175	4	3	0	3	0	3	0	13
Buffalo	580,132	1	2	-	-	-	1	1	5
Manh'tan	1,960,101	2	20	6	13	0	2	0	43
Ohio Clev'nd	914,808	7	6	4	16	1	2	-	36
Cincin	503,998	13	18	9	-	22	6	-	68
Pa Phila	2 071,605	5	9	9	115	11	9	-	158
Wis Milw kee	637,392	6	22	13	27	4	2	-	74
Total		159	269	138	297	55	47	23	988

TABLE 42

NUMBER OF ENGINEERING POSITIONS AFFECTED BY CONSULTANTS
Group IV Cities (Population over 500,000)

State and City	Pop.	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint.	Other	Total
Calif Los Ang's	2,104,663	-	-	-	-	-	-	-	0
San Fran.	775,357	0	0	0	0	0	0	0	0
Ill. Chicago	3,620,962	10	10	70	-	-	-	-	90
La New Orlea	570,445	-	-	-	-	2	-	-	2
Mass Boston	801,444	-	-	-	-	-	-	-	0
Mich. Detroit	1,849,568	-	-	-	-	-	-	14	14
Minn. Minne'lis	521,718	-	-	-	-	-	-	-	0
Mo St Louis	856,796	-	1	3	-	-	-	-	4
N Y Brooklyn	2,738,175	10	4	15	0	0	0	0	29
Buffalo	580,132	-	-	2	1	1	-	-	4
Manh'tan	1,960,101	0	0	0	0	0	0	0	0
Ohio Clev'nd	914,808	-	14	4	-	-	-	-	18
Cincin	503,998	-	12	13	-	-	-	-	25
Pa. Phila	2,071,605	-	5	8	5	-	-	-	18
Wis Milw'kee	637,392	-	-	-	-	-	-	-	0
Total		20	46	115	6	3	0	14	204

TABLE 43

NUMBER OF PROFESSIONAL ENGINEERS DESIRED IN ADDITION TO (1) AND (2)
Group IV Cities (population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint.	Other	Total
Calif Los Ang's	2,104,663	7	18	3	3	3	-	-	34
San Fran.	775,357	5	3	0	0	1	0	1	10
Ill. Chicago	3,620,962	5	10	20	10	-	-	-	45
La New Orlea	570,445	2	2	2	2	-	2	1	11
Mass Boston	801,444	-	-	-	-	-	-	-	0
Mich. Detroit	1,849,568	4	23	18	4	1	0	4	54
Minn. Minne'lis	521,718	2	2	2	1	-	1	-	8
Mo St Louis	856,796	3	0	3	0	0	0	0	6
N Y Brooklyn	2,738,175	6	0	0	3	1	1	0	11
Buffalo	580,132	-	1	-	1	1	-	-	3
Manh'tan	1,960,101	0	0	0	0	0	0	0	0
Ohio Clev'nd	914,808	2	2	2	-	-	-	-	6
Cincin.	503,998	2	10	8	-	5	-	-	25
Pa. Phila	2,071,605	1	2	2	82	11	10	-	108
Wis Milw'kee	637,392	1	2	4	2	-	1	-	10
Total		40	75	64	108	23	15	6	331

TABLE 44

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Los Ang's.	2,104,663	53	232	40	16	4	-	-	345
San Fran	775,357	13	21	2	4	3	5	12	60
Ill. Chicago	3,620,962	25	25	72	62	6	-	-	190
La. New Orlea.	570,445	6	8	2	5	-	5	2	28
Mass. Boston	801,444	8	9	6	36	3	3	1	66
Mich. Detroit	1,849,568	36	50	26	15	1	2	-	130
Minn. Minne'lis	521,718	7	6	5	6	2	5	-	31
Mo St Louis	856,796	8	1	1	11	5	7	-	33
N. Y Brooklyn	2,738,175	4	3	-	3	-	3	-	13
Buffalo	580,132	1	2	-	-	-	1	1	5
Manh'tan	1,960,101	2	22	6	14	-	3	-	47
Ohio Clev'nd	914,808	7	7	6	17	1	-	-	38
Cincin	503,998	20	25	18	30	-	7	-	100
Pa. Phila	2,071,605	8	13	12	202	24	22	-	281
Wis Milw'kee	637,392	8	27	19	32	4	3	-	93
Total		208	451	215	453	53	66	16	1460

TABLE 45

MINIMUM NUMBER OF PROFESSIONAL ENGINEERS REQUIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop.	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint.	Other	Total
Calif Los Ang's	2,104,663	64	348	60	24	6	-	-	502
San Fran	775,357	15	23	2	5	3	5	14	67
Ill. Chicago	3,620,962	30	30	90	75	7	-	-	232
La. New Orlea	570,445	5	7	1	4	1	4	-	22
Mass Boston	801,444	10	10	8	40	3	3	1	75
Mich. Detroit	1,849,568	40	60.	32	18	2	4	0	156
Minn. Minne'lis	521,718	8	7	6	7	3	5	-	36
Mo St. Louis	856,796	11	-	-	14	7	9	-	41
N Y Brooklyn	2,738,175	4	3	-	3	-	3	-	18
Buffalo	580,132	2	3	1	2	1	1	2	12
Manh'tan	1,960,101	2	24	6	18	-	4	-	54
Ohio Clev nd	914,808	6	3	3	20	-	-	-	32
Cincin	503,998	24	30	20	35	-	8	-	117
Pa. Phila	2,071,605	9	15	13	225	27	24	-	313
Wis Milw kee	637,392	9	30	21	35	4	3	-	102
Total		206	451	215	453	53	66	16	1779

TABLE 46

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 25 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint.	Other	Total
Calif Los Ang's	2,104,663	61	268	46	22	10	-	-	407
San Fran.	775,357	13	23	2	4	3	5	13	63
Ill. Chicago	3,620,962	30	40	100	70	10	-	-	250
La. New Orlea.	570,445	6	8	2	5	-	5	3	29
Mass Boston	801,444	8	9	6	36	3	3	1	66
Mich. Detroit	1,849,568	42	60	36	20	3	3	10	174
Minn. Minne'lis	521,718	8	7	6	7	3	5	-	36
Mo St Louis	856,796	13	5	8	4	4	2	-	36
N. Y Buffalo	580,132	1	4	-	1	1	1	1	9
Brooklyn	2,738,175	10	3	-	6	1	4	-	24
Manh'tan	1,960,101	2	22	6	14	-	3	-	47
Ohio Clev'nd	914,808	10	9	8	19	1	-	-	47
Cincin	503,998	24	31	22	32	-	8	-	117
Pa. Phila	2,071,605	8	13	13	204	25	24	-	287
Wis Milw kee	637,392	8	29	21	34	5	3	-	100
Total		244	531	276	478	69	66	28	1692

TABLE 47

OPTIMUM NUMBER OF PROFESSIONAL ENGINEERS DESIRED FOR PROGRAM EXPANDED BY 50 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Los Ang's	2,104,663	74	402	69	33	15	-	-	593
San Fran	775,357	18	25	2	5	3	5	14	70
Ill. Chicago	3,620,962	35	50	110	80	15	-	-	290
La. New Orlea	570,445	5	7	1	4	1	4	1	23
Mass Boston	801,444	10	10	8	40	3	3	1	75
Mich. Detroit	1,849,568	50	75	48	30	4	6	10	223
Minn. Minne'lis	521,718	9	8	7	8	4	6	-	42
Mo St Louis	856,796	18	5	8	8	8	4	-	51
N Y Brooklyn	2,738,175	12	4	-	6	1	4	-	27
Buffalo	580,132	1	4	-	2	1	2	2	12
Manh tan	1,960,101	2	24	6	18	-	4	-	54
Ohio. Clev'nd	914,808	9	8	6	22	1	-	-	46
Cincin	503,998	28	38	25	38	-	10	-	139
Pa Phila	2,071,605	9	15	15	235	29	26	-	329
Wis Milw'kee	637,392	9	32	25	37	5	4	-	112
Total		287	707	330	566	90	78	28	2086

TABLE 48

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 25 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint.	Other	Total
Calif Los Ang's	2,104,663	-	-	-	-	-	-	-	-
San Fran	775,357	2	4	4	-	-	-	-	10
Ill. Chicago	3,620,962	10	10	70	-	-	-	-	90
La. New Orlea.	570,445	2	2	2	2	2	2	2	14
Mass Boston	801,444	-	-	-	-	-	-	-	-
Mich. Detroit	1,849,568	-	-	-	-	3	-	30	33
Minn Minne lis	521,718	-	-	-	-	-	-	-	-
Mo St Louis	856,796	-	5	5	-	-	-	-	10
N Y Brooklyn	2,738,175	10	4	15	-	-	-	-	29
Buffalo	580,132	-	-	2	1	1	-	-	4
Manh'tan	1,960,101	-	-	-	-	-	-	-	-
Ohio Clev'nd	914,808	2	15	6	-	2	-	-	25
Cincin	503,998	-	25	20	-	-	-	-	45
Pa. Phila	2,071,605	-	-	-	-	-	-	-	-
Wis Milw'kee	637,392	-	-	-	-	-	-	-	-
Total		26	65	124	3	8	2	32	260

TABLE 49

NUMBER OF POSITIONS EXPECTED TO BE FILLED BY CONSULTANTS FOR PROGRAM EXPANDED BY 50 PERCENT
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater. & Tests	Maint	Other	Total
Calif Los Ang's	2,104,663	-	-	-	-	-	-	-	-
San Fran	775,357	3	7	6	-	-	-	-	16
Ill. Chicago	3,620,962	20	20	100	-	-	-	-	140
La. New Orlea	570,445	4	4	4	4	2	4	4	26
Mass Boston	801,444	-	-	-	-	-	-	-	-
Mich. Detroit	1,849,568	-	-	-	-	4	-	40	44
Minn. Minne lis	521,718	-	-	-	-	-	-	-	-
Mo St Louis	856,796	-	10	10	-	-	-	-	20
N Y Brooklyn	2,738,175	10	5	15	1	-	1	-	32
Buffalo	580,132	-	-	3	1	1	-	-	5
Manh tan	1,960,101	-	-	-	-	-	-	-	-
Ohio Clev'nd	914,808	5	22	12	-	4	-	-	43
Cincin	503,998	-	30	25	-	-	-	-	55
Pa. Phila	2,071,605	-	-	-	-	-	-	-	-
Wis Milw'kee	637,392	-	-	-	-	-	-	-	-
Total		42	98	175	6	11	5	44	381

TABLE 50

NUMBER OF POSITIONS TO BE VACATED BY RETIREMENT DURING NEXT 10 YEARS
Group IV Cities (Population over 500,000)

State and City	Pop	Plan & Traffic	Street Design	Bridge Design	Constr	Mater & Tests	Maint	Other	Total
Calif Los Ang's	2,104,663	18	60	12	4	1	-	-	95
San Fran	775,357	1	3	1	8	0	2	4	19
Ill. Chicago	3,620,962	4	4	10	10	1	-	-	29
La New Orlea	570,445	1	0	0	2	0	0	3	6
Mass Boston	801,444	1	1	2	4	1	1	-	10
Mich. Detroit	1,849,568	6	6	6	10	1	1	6	36
Minn. Minne lis	521,718	-	1	1	-	1	1	-	4
Mo St. Louis	856,796	-	-	-	-	-	-	-	0
N Y Brooklyn	2,738,175	3	2	0	1	0	1	0	7
Buffalo	580,132	-	1	-	-	-	1	1	3
Manh'tan	1,960,101	0	4	0	6	0	1	0	11
Ohio Clev'nd	914,808	3	2	2	6	-	-	-	13
Cincin.	503,998	3	6	5	4	3	-	-	21
Pa. Phila	2,071,605	-	1	2	11	-	3	-	15
Wis Milw'kee	637,392	1	10	2	2	-	-	-	7
Total		41	101	43	66	8	11	14	286

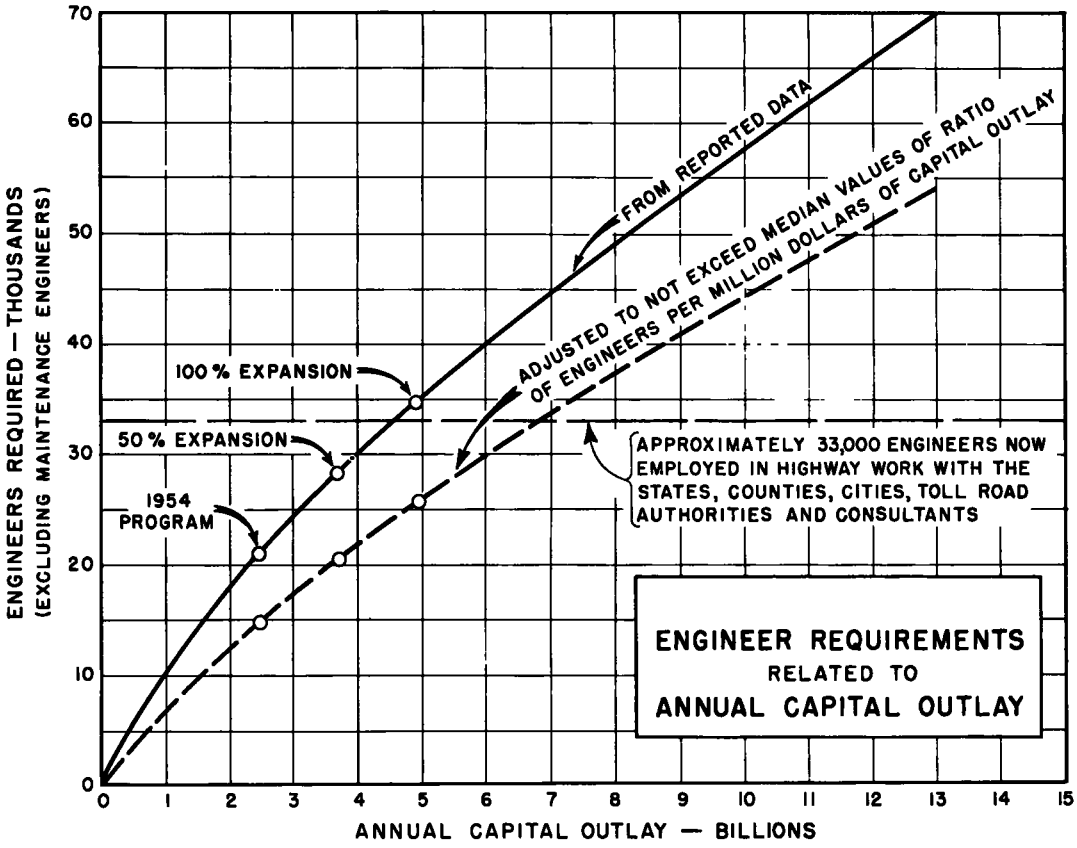

Figure 5.

toll road authorities and consultants, a total of about 33,000 is indicated, which is far short of the number needed. Recruitment of new graduates can and should be increased, but that provides relatively little help. It appears that the solution lies in more-effective application of the engineering talent available, both by care in planning assignments and in the increased use of photogrammetry, standard plans, uniform geometrics, mechanization of procedures, and other time- and labor-saving devices.

POTENTIALITIES IN BETTER ENGINEER UTILIZATION AND IMPROVED METHODS

To explore possibilities in that direction a computation was made to determine what reduction in total need would result if the highway departments with ratios of engineers per million dollars of capital outlay higher than the median values mentioned previously could reduce their ratios to the median values. This was done for the 1954 program and the 50-percent-larger and the 100-percent-larger programs, which gave a reduced number of engineers for each of the three capital outlay amounts.

These results were plotted to obtain a curve similar to that in Figure 4. This curve, with the Figure 4 curve plotted with it, is shown in Figure 5.

For a $10-billion annual rate of capital outlay there is indicated a reduction in need from 58,000 engineers to 44,000, a considerable improvement, but still appreciably more than the number now employed. While this is, of course, an approximate comparison, there are indicated possibilities inherent in more-effective engineer utilization, and certainly there is indicated the value of giving careful consideration to the adoption of all measures possible to relieve engineers of duties which can be performed adequately by clerical and subprofessional personnel, to the increased use of economists, statisticians, accountants, and right-of-way specialists and to greater use of streamlined methods.

The number of engineers which will be actually needed in each state, county or city will, of course, depend on its part of the program finally adopted, as well as on internal operating improvements. This cannot be determined until the magnitude of the total program is definite and until the details, including the rate of anticipated annual expansion and the distribution of work to be accomplished, have been fully developed and accepted.

If a program of the magnitude proposed by the Advisory Committee on a National Highway Program is adopted, the increase in annual capital outlay necessarily will be gradual. There will be time for each highway department to study its own situation and to prepare for increasingly heavy loads as the total program expands. The study covered in this report indicates that the engineer-personnel situation, while requiring immediate attention, may not become critical until about the fourth or fifth year of the proposed program (that is, in 1958 or 1959 if the program is initiated in 1955). It need not become critical if adequate preparation is made.

MORE-COMPLETE STUDY DESIRABLE

The canvass covered in this report concerned only professional engineer personnel. A study should be made of the subprofessional personnel area to determine the demand-supply situation, most effective utilization, and development of intensive training courses.

The technical-personnel situation obviously will be a controlling factor in the successful accomplishment of the proposed program, and a much-more-exhaustive study of the entire technical-personnel field than has been attempted up to now would be helpful in pointing out ways and means of meeting this unprecedented challenge to the highway profession.

Use of Private Firms for Highway-Engineering Functions

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● INCREASING rates of highway building throughout the nation and prospects of further increases have raised a number of diffficult 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]	Topographic maps[b]	Preliminary route surveys	Foundation studies, material surveys	Roadway design, plans, specs.	Bridge design, plans, specs.	Supervision of construction	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
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 construction 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 no-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 manitaining 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.

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