Technical Institute Training for Highway Engineering Technicians

T. L. BRANSFORD AND L. L. SMITH,

Respectively, Engineer of Research and In-Service Training and Assistant Research Engineer, State Road Department of Florida

In this paper the curricula of approximately 30 junior colleges and technical institutes are analyzed to determine the types of educational programs being offered that would be of benefit to the prospective employees of a State highway department in a subprofessional or technician classification. Curricula are evaluated on the basis of courses included, course contents, and field and laboratory applications to actual practice.

The advantages of junior college and technical institute training to the employee and to the highway department are discussed. The place of an employee with this training in the engineering organization of a State highway department for his initial assignment and his opportunities for a career in highway engineering and eventual advancement from a subprofessional to a professional classification are explored.

Finally, a recommended two-year terminal curriculum is developed for those persons who are specifically interested in going into highway engineering at the subprofessional level.

• AT THE 40th Annual Meeting of the Highway Research Board, the Committee on Education and Training of Highway Engineering Personnel discussed at some length the training and education the growing number of technical institutes in the United States were offering in the field of Civil Technology that would be of particular interest and benefit to the high school graduate who wished to prepare himself for a career in engineering in one of the State highway departments but did not feel that he could take a formal four-year course in Civil Engineering. Of those in attendance only a few had the vaguest idea of what was being offered at any schools other than possibly one in their own immediate localities. It was decided that it would be of interest to the entire group for a survey to be made of all the known technical institutes in the United States and determine the over-all picture of their curriculum offerings as they related to highway engineering.

This was a matter of keen interest to the author not only because of his responsibility for training engineering employees for the State Road Department of Florida but also because of his co-chairmanship of a State advisory committee for technical education for the Florida Department of Education which is rapidly expanding the State junior college system and technical education programs within the junior colleges. Subsequently, M. L. Archer, Kentucky Highway Department; R.

J. Paquette, Georgia Institute of Technology; and L. Csanyi, Iowa State College, volunteered their assistance. Also, L. L. Smith, Assistant Research Engineer, State Road Department of Florida, was pressed into service to assist in analyzing the information.

The first step in making the survey was to secure a list of all technical institutes and junior colleges in the United States. This was obtained from the Florida State Department of Education with the cooperation of the U. S. Department of Education.

The list included 56 schools. A letter was prepared asking each school to furnish a copy of its latest catalogue with course description, if it offered a curriculum in Civil Technology or closely related to Civil Technology. Thirty-eight schools complied with the request and supplied the requested materials. Several others replied saying that their new catalogues would be out shortly and they would send one immediately, though they never did. Because the response was 66 percent, it was thought that this was sufficient to get a representative sampling and no follow-up was made for those who promised catalogues but did not send them.

The distribution of schools by State was California, eight; Florida, six; Oregon, five; North Carolina, four; Wisconsin, three; New York and Colorado, two each; and North Dakota, Indiana, Pennsylvania, Massachusetts, Missouri, Mississippi, Georgia, and Michigan, one each. It was felt that this was good geographic distribution.

Three of the 38 schools had a one-year terminal curriculum and the other 35 offered a two-year terminal curriculum.

The titles of the curricula varied among the schools. In 3 schools they were designated as Pre-Engineering; in 3, Engineering Aide; in 3, Engineering Technology; in 4, Surveying Technology; in 8, Highway Technology; in 1, Construction Technology; and in 16, Civil Technology.

In reviewing the curricula of these schools it must be borne in mind that the only information available was the catalogues. In these the course titles can be misleading and the course description so general that it is difficult to pinpoint what is actually being taught. However, an attempt was made to group the courses in general areas and the following discussion of the curricula is on the basis of this information.

The three schools offering a one-year terminal curriculum were similar in that one required 32 semester hours credit for graduation, the second 33 semester hours, and the third 45 quarter hours, which is equivalent to 30 semester hours. In all three cases, none of the courses was intended to be transferable for college credit.

As to the title of the curriculum, one was called Civil Engineering Aide and the other two Highway Technology.

A further look at the curricula showed that the school with the Engineering Aide curriculum actually required more courses to be taken in the highway field than did either of those designated Highway Technology (Table 1). In the Engineering Aide curriculum 7 semester hours of highway engineering were required but none in the other two. In other subjects, the three schools have relatively equivalent requirements except the one with the Engineering Aide curriculum is low on its requirements in English and physics which allows the 7 hours of highway engineering to be included without increasing the over-all total of required number of hours.

It can be concluded that all three of these schools had as their objectives for these curricula very concentrated training for technicians in-

TABLE 1
CURRICULUM, ONE-YEAR SCHOOLS

Subjects	Engineering Aide (semester hr)	Highway Technology (quarter hr)	Highway Technology (semester hr)
General education	3	0	4
English	2	9	4
Algebra and trigonometry	6	9	4
Physics	2	8	6
Drawing	5	6	4
Plane surveying	2	9	4
Route surveying	3	0	4
Highway engineering	7	0	0
Topographic mapping	0	2	0
Testing and inspection	2	0	2
Construction methods	0	1	1
Total	32	45	33

terested in entering the highway engineering field in either surveying, roadway design, or possibly construction inspection.

A detailed study of the curricula for the other 35 schools, all of which offer two-year terminal programs, reveals again that the title of the curriculum is not in keeping with the types of courses included. On the other hand, the curricula of all 35 do have a number of features in common (Table 2).

For example, 33 of the 35 schools include English as a requirement for a degree. The number of hours required in English varies from a maximum of 10 semester hours to a minimum of 3 semester hours. One school which does not require any English requires 1 semester hour of report writing. Two schools require 6 hours

TABLE 2
CREDIT HOURS,[1] TYPICAL COURSES
TWO-YEAR CURRICULA

School Number	Curriculum Title	English	Report Writing	Mathematics	Chemistry	Physics	Drawing	Surveying	Highway Engineering	Soil Mechanics	Properties of Materials	Testing and Inspection	Construction Methods	Engineering Mechanics	Structural Design
1	Pre-Engr.	3	—	17	10	12	4	3	—	—	3	—	—	3	—
2	Pre-Engr.	6	—	16	8	10	6	—	—	—	—	—	—	3	—
3	Pre-Engr.	6	—	12	10	12	4	6	—	—	2	—	—	3	—
4	Engr. Aide	6	—	20	—	8	9	—	—	—	3	2	—	6	—
5	Engr. Aide	—	1	5	—	3	6	18	—	2	—	—	—	—	2
6	Engr. Tech.	6	—	3	—	8	8	6	—	—	—	—	—	—	—
7	Engr. Tech.	6	—	6	—	—	4	6	—	—	3	—	—	6	—
8	Engr. Tech.	6	—	9	8	8	6	—	—	—	—	—	—	—	5
9	Surv. Tech.	6	3	13	—	3	2	23	—	—	—	—	—	3	—
10	Surv. Tech.	3	—	—	—	6	2	20	—	4	—	—	—	—	—
11	Surv. Tech.	3	—	12	—	—	13	16	—	—	2	—	—	—	—
12	Surv. Tech.	10Q	3Q	10Q	—	12Q	10Q	27Q	3Q	—	2Q	2Q	—	7Q	—
13	Hwy. Tech.	9Q	—	8Q	—	6Q	11Q	12Q	2Q	—	—	—	8Q	7Q	11Q
14	Hwy. Tech.	12Q	—	15Q	—	8Q	9Q	16Q	8Q	3.5Q	—	—	5Q	16Q	9.5Q
15	Hwy. Tech.	6Q	3Q	11Q	—	8Q	8Q	35Q	—	4Q	—	—	—	8Q	4Q
16	Hwy. Tech.	6	—	6	—	4	6	6	6	—	2	3	6	3	4
17	Hwy. Tech.	6Q	3Q	9Q	—	8Q	6Q	23Q	4Q	6Q	—	—	—	6Q	2Q
18	Const. Tech.	10Q	3Q	10Q	10Q	12Q	10Q	9Q	3Q	—	2Q	2Q	3Q	7Q	8Q
19	Civil Tech.	6	—	4	—	3	8	15	—	—	3	—	—	3	—
20	Civil Tech.	5	2	6	3	8	5	7	2	—	2	2	—	5	3
21	Civil Tech.	9Q	—	9Q	—	12Q	21Q	9Q	—	—	—	—	—	6Q	—
22	Civil Tech.	6	3	9	4	8	6	6	4	—	—	—	—	7	—
23	Civil Tech.	6	—	12	4	8	4	5	3	—	—	—	—	7	—
24	Civil Tech.	9Q	—	10Q	10Q	15Q	18Q	7Q	—	—	—	—	—	—	—
25	Civil Tech.	9	—	14	—	6	13	4	—	—	1	—	—	12	14
26	Civil Tech.	6	—	9	—	6	4	6	—	—	—	—	—	—	—
27	Civil Tech.	6	2	10	5	5	11	9	—	—	2	—	—	3	—
28	Civil Tech.	6	3	6	8	8	12	9	3	—	—	—	—	3	—
29	Civil Tech.	6	—	6	—	4	7	11	—	—	—	—	—	3	—
30	Civil Tech.	6Q	3Q	10Q	5Q	16Q	6Q	22Q	3Q	—	3Q	—	4Q	7Q	10Q
31	Civil Tech.	—	—	9	—	15	18	21	—	—	—	—	—	8	21
32	Civil Tech.	6Q	—	11Q	—	8Q	6Q	24Q	3Q	6Q	4Q	1Q	—	8Q	2Q
33	Civil Tech.	6	3	8	—	8	6	3	3	—	—	—	—	6	3
34	Civil Tech.	9Q	—	27Q	—	12Q	9Q	19Q	5Q	—	—	—	2Q	3Q	3Q
35	Civil Tech.	10	2	10	—	12	6	10	2	—	—	6	3	—	—

[1] Q denotes quarter hours; all others are semester hours.

of English plus 3 hours of report writing and one requires 10 semester hours of English plus 2 of report writing. The average amount of English required is 6 semester hours.

In the field of mathematics, 7 of the 35 schools offer a course entitled Technical Mathematics which in general is a review of high school algebra but also goes into college algebra and trigonometry. The number of semester hours required varies from a maximum of 9 to a minimum of 2, with 6 being the most common requirement.

Ten of the two-year schools require from 4 to 10 hours of a course called General College Mathematics, with 8 hours being the predominant requirement. This course is more advanced than the Technical Mathematics course and has an introduction to calculus.

In trigonometry, 17 schools require the almost unanimous 3 semester hours. One school does not require any trigonometry but requires it for admission. Sixteen other schools teach trigonometry through a course in either Technical Mathematics or General College Mathematics.

Five schools require from 3 to 10 semester hours of calculus. One school requires 3 semester hours of differential equations.

The curricula for all schools requiring calculus are made up entirely of courses that are acceptable for college credit or a large number of courses that are transferable for college credit.

The total amount of mathematics required for a degree in the two-year schools surveyed varies from 3 to 20 semester hours. The curricula that include calculus vary in their mathematics requirements from 14 to 18 semester hours.

Thirty-three 2-year schools require physics for an associate degree. The number of hours required varies from 3 to 15 semester hours. The median requirement is 8 semester hours.

Chemistry is required by 12 schools with 3 to 10 semester hours being required for an associate degree. In general, those requiring 8 to 10 semester hours have curricula composed of courses the majority of which are transferable for college credit.

Approximately 50 percent of the 35 two-year curricula surveyed are made up of courses that are transferable for college credit. By curricula titles, one is called Engineering Aide, one Engineering Technician, three Pre-Engineering, three Surveying Technology, one Construction Technology, and the balance Civil Technology.

Engineering drawing is required in all the schools surveyed, and 15 of the two-year schools require descriptive geometry. Fourteen schools require a course in structural drawing. Combining engineering drawing, descriptive geometry, and structural drawing, the total amount of drawing required at all schools varies from 2 to 14 semester hours. The median is 8 semester hours.

Thirty-two schools require from 3 to 21 semester hours of plane surveying and 23 require from 2 to 6 semester hours of route surveying. The median is approximately 6 semester hours of combined plane and route surveying. In many instances both are taught under the course title of Plane Surveying.

Geodetic surveying is taught in 3 two-year schools and photogrammetry in 4. Topographic surveying is required in 17 schools.

The total of semester hours of combined surveying courses required in all two-year schools varies from 3 to 23. The maximum of 23 hours is in a curriculum entitled Surveying Technology and the other three schools surveyed with the same curriculum title require 20, 16, and 18 semester hours. On the other hand, one curriculum designated as Civil Technology requires 21 semester

hours and one in Highway Technology requires 24 hours.

Sixteen schools teach highway engineering. No two courses appeared to be the same. They varied from highway construction, highway surveying, highway drafting, to traffic engineering. One was devoted to drainage, and several were primarily route surveying.

Approximately 50 percent of the schools with curricula in Civil Technology had requirements in highway engineering, and 3 of the 7 with curricula designated as Highway Technology had no requirement in highway engineering as a designated course.

Six schools required instruction in geology, 6 soil mechanics, 13 fluid mechanics or hydraulics, 3 water supply and sewage, 5 shops, 14 properties of materials, 7 testing and inspection procedures, and 7 construction methods.

Seventeen of the two-year schools require a course in statics, 15 require strength of materials, 2 require dynamics, and 8 require engineering mechanics. Because there is an overlapping of subject matter taught under these titles in most of the schools it would be more realistic to analyze the offerings of the three courses as one group and designate it as Engineering Mechanics.

On this basis, 27 of the 35 schools offer either single or a combination of courses in the field of engineering mechanics. On the basis of semester hours required, they vary from 3 to 12, with 6 being the possible median.

In the field of structural design 6 schools require courses in structural analysis, 7 in steel and timber design, 7 in reinforced concrete design, and 6 in plane concrete design.

Again, grouping these courses under a general title of Structural Design, 15 of the 35 schools have offerings in this area with the requirement ranging from 2 quarter hours to 21 semester hours with actually no real median being common to the majority of schools.

This discussion has purposely omitted the nontechnical or cultural courses. Most schools require varying amounts of these and they include physical education, health and hygiene, history, humanities, economics, American institutions, etc.

Before closing, it probably would be of interest to point out that the total number of hours on a semester basis required for a degree from the two-year colleges varies from a minimum of 60 to a maximum of 82. In some cases physical education is included in the totals and in others it is excluded. The school requiring 82 semester hours is on a quarter system and the total of quarter hours is 124. To complete the requirements for a degree in Highway Technology at this school in six quarters a student must complete 22 hours per quarter for two quarters and 21½ hours in another quarter, and these totals do not include physical education. This is a difficult schedule for any student. In fact, a student completing this curriculum would have two-thirds of the technical course hours normally required for a four-year college degree.

A graduate of a two-year technical education program such as those just discussed who plans to go into highway work should have a well-rounded subprofessional knowledge of highway engineering. He should be able with a minimum of instruction at the very beginning to direct the work of a surveying party either on location or construction under the general supervision of a professional engineer. (Here a professional engineer is considered an engineer who by experience and education is qualified to direct the work of several engineering subordinates, is in charge of an engineering project of a rather complex nature either on construction or design, and may or may not be a registered professional engineer.) He should be able to handle assignments

in a drafting room (either on roadway or on structural design) or in a materials testing laboratory, and as an inspector on construction directing the work of one or more subordinates and under the general supervision of a professional engineer.

The principal objective of such a program should be to teach the student why he does certain things in the way he does them, the possible causes and effects of errors, as well as ways of correcting them, and to a lesser degree the skill and efficiency with which he should be able to carry out his assignments. Skills and efficiency are developed in actual practice and cannot be taught in a two-year curriculum. If a man is given the academic background to understand the fundamental principles involved in the engineering assignments he will get in practice, he will develop proficiency through on-the-job practice.

If the prospective employee is to have a well-rounded training for these subprofessional assignments, he must have instruction in the following subjects:

1. Plane surveying.
2. Route surveying.
3. Algebra.
4. Analytic geometry.
5. Trigonometry.
6. Drawing.
7. Descriptive geometry.
8. Physics.
9. Engineering mechanics.
10. Strength of materials.
11. Properties of materials.
12. Elementary soil mechanics.
13. Highway engineering.
14. Structural drawing.

These are all fundamental courses on which the technician can build his knowledge by actual practice and further study. In addition, such courses as economics, history, and humanities will add to his mental training and over-all knowledge.

English is a must if a technician has any ambition at all. He must be able to organize his thoughts, write using correct grammar, and also communicate verbally. In addition, adequate training in English will add to his ability to read and properly interpret specifications, written instructions, and other documents. There is nothing more discouraging than to have a technically trained employee who cannot effectively communicate with his superiors either verbally or in writing.

From the student's standpoint it is highly desirable for the basic courses, at least, mathematics, surveying, physics, English and possibly engineering mechanics, to be taught at the college level so that they can be used for college credit if desired. The author has known several highway employees who have graduated from a technical institute and then decided to go to an accredited four-year engineering college where none of their technical institute credits were acceptable. There are others who would have liked to have gone to a four-year college but could not afford the six to seven years it would have required, counting the two years they had already spent on a two-year curriculum for which they could not get credit in a four-year college.

A curriculum meeting the stated requirements would at least be similar to the one in Table 3. A person having completed this curriculum would be qualified for a position generally classified in most highway departments as an Engineering Aide III. He ought to feel equally at home on an initial assignment to materials testing and inspection, drafting and computations either in roadway design or structural design; construction inspection; office computations on construction; or surveying either on construction or location.

The question arises as to what the future would have to offer a person

TABLE 3
RECOMMENDED CURRICULUM

Semester One	Hours	Semester Two	Hours
		(a) First Year	
English	3	English	3
Algebra	3	Trigonometry	3
American government	3	Physics	4
Engineering drawing	3	Descriptive geometry	3
Chemistry	4	Economics	3
Total	16		17
		(b) Second Year	
Report writing	3	Soil mechanics	3
Analytic geometry	4	Route surveying	3
Physics	4	Strength of materials	4
Plane surveying	3	Highway engineering	3
Engineering mechanics	3	Structural drawing	2
		Properties of materials	2
Total	17		17

in a highway department with this type of training. Under present classification systems in some highway departments, he would be stymied after two or three years. In others, he could advance to possibly a resident engineer position on construction or a district materials engineer position and may be a squad leader's position in a drafting room in a reasonable time.

The growth of the number of schools offering a two-year terminal curriculum in Civil Technology or its equivalent is rapid, and it would be to the advantage of all highway departments to establish career ladders for technicians (separate and distinct from those for the engineer) that would lead to a position requiring registration as a professional engineer. At this point a technician should be able to attain an engineer title on the assumption that as a registered professional engineer it is immaterial whether his background includes a degree from a four-year accredited engineering college or a two-year accredited technical institute or junior college.

As a technician advances up the technician career ladder he would receive compensation in some instances comparable to an engineer classification. However, as a general rule he would be a specialist—his administrative responsibilities would not be as great as those of a person in a financially comparable engineer position but his responsibility for the technical adequacy of this work would be equivalent to or even greater than that of the engineer.

If the suggested model curriculum for a two-year program is compared with the 35 programs surveyed, only 21 offer courses in structural drawing or some type of structural design that undoubtedly includes structural drawing. Therefore, on this score 14 would not comply with the model curriculum, and in line with the philosophy expressed in this paper these schools are not particularly concerned with training technicians who might be interested in working in the structural design section of a highway department.

Twenty-nine schools do not offer soil mechanics as a separate course, although some may have a minimum amount of instruction in this subject included in some other course. Twenty-one do not offer a course

designated as Properties of Materials. It appeared that the training of technicians for materials and testing is not a primary objective of a majority of the schools surveyed, but here again, some of the subject matter normally taught under this title may be included in another course or other courses. Construction methods is not included in 28 curricula.

Turning now to what might be termed the basic courses in Civil Engineering, three junior colleges, all in Florida, do not include surveying in their curriculum. One which has a program in surveying technology does not offer any course in mathematics. Eight do not offer instruction in engineering mechanics. One school does not require any English or report writing.

From this survey it must be concluded that approximately 20 of the 35 two-year curricula are designated to train technicians who are interested in going into either highway construction, roadway design, materials testing and inspection, or structural design. The use of the word "approximately" is necessary because the survey is based on course titles and catalogue descriptions which are inadequate for a detailed analysis. Approximately 26 have curricula designed to train a person for a technician's position in a highway department either on construction, location, or roadway design.

Unfortunately, the number of graduates estimated for each of the curricula annually was not available for this study. However, it can be seen that the technical institutes and junior colleges are a source of supply for technicians which are badly needed by most highway departments. The number of schools and the number of students are both increasing rapidly so that there will apparently by a substantial supply of academically trained technicians for highway work in the not too distant future. As this day approaches some highway departments may be able to curtail or terminate some of the training that they are now having to do with their own personnel. Also, it will relieve the professional engineers of some of their routine tasks and make them truly professional engineers.