Attracting Students to a Professional Career in Transportation Engineering

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PREFACE

The great difficulty that employers, including universities, have had recently in finding engineering graduates to fill vacancies is a frequent topic of discussion among civil engineering professionals. This is especially true when seeking high quality engineering graduates in transportation engineering. The condition was brought to the attention of the Technical Council of the Institute of Transportation Engineers, and following extensive discussion, it was determined to be a subject of great importance that should be a topic of study and investigation. Subsequently, a committee was appointed, and I accepted an invitation to chair the committee and conduct a study that would investigate the problem. The result of the study was basically this report. The committee began its study in early 1986 and submitted its report in 1988.

INTRODUCTION

In initiating this study, it quickly became obvious that most transportation engineering professionals historically and currently are products of a civil engineering education. As a consequence, a study of the current status of civil engineering graduates was determined to be fundamental. The current shortage of graduates interested in transportation engineering was found to exist at all levels of education, B.S. and M.S. degrees at the transportation industry level of interest, and Ph.D. degrees at the university faculty level. The study began with existing conditions (1986 through 1987) for each of the degrees.

NUMBER OF CIVIL ENGINEERING GRADUATES

The total number of bachelor's degrees awarded in civil engineering, as documented by the Engineering Manpower Commission over the 12-year period from 1976 to 1987, is shown in Table 1. In 1987, the number was still low. Because of lesser numbers of students in the four-year pipeline, the number will likely continue to be low every year until 1991 or 1992. Universities, however, reported a slight increase in enrollment for civil engineering in the fall of 1987, and the outlook for the fall of 1988 is even better.

The decreasing number of B.S. graduates in civil engineering especially since 1979 surprisingly occurred during a period when the number of B.S. degrees awarded in all of engineering doubled, between 1976 and 1987. During the same period, the number of B.S. degrees in all of engineering tended also to increase
and, relative to 1976, was 47 percent higher in 1987. For civil engineering, however, during the period from 1976 to 1987 there was actually a slight decrease. Between 1976 and 1987, the number of Ph.D. graduates increased 40 percent for all engineering disciplines, but only 30 percent for civil engineering majors. The increase in the number of graduate degrees awarded recently, moreover, was significantly affected by the large number of graduate degrees in engineering awarded to foreign students, as shown in Table 2. Although only 8 percent of B.S. degrees were received by foreign nationals, 25 percent of the M.S. degrees and more than 40 percent of the Ph.D. degrees were awarded to such students. In civil engineering, the percentages of degrees awarded to foreign nationals in 1986 and 1987 were even greater. The decrease in total graduates in civil engineering at the B.S. and M.S. levels during the last five years has been especially significant. When one considers the large number of foreign graduates obtaining advanced degrees, the serious decrease of available graduates exists at all levels of study. Certainly, it should be no surprise that the number of civil engineers with interest in transportation engineering has also been decreasing.

QUALITY OF RECENT CIVIL ENGINEERING STUDENTS

Of greater significance than the quantity of civil engineers is the quality of them. First, let’s look at some experiences at Purdue University. If one examines the high school rank and SAT scores of incoming freshman and their first semester grade point average at Purdue for the four major engineering schools during the last several years, a definite pattern is clear. Students in chemical engineering are on top in each measurement and civil engineering students are on the bottom. Those in electrical engineering and in mechanical engineering are higher in all measures than those in civil engineering. Furthermore, civil engineering rarely obtained any of the 75 or so honor students who enter Purdue engineering each year, and civil engineering graduating classes included noticeably fewer distinguished students.

Purdue University, however, is not unique in this matter. Professor James McDonough of the University of Cincinnati reported at an American Society of Civil Engineers (ASCE) conference on civil engineering education the results of a survey of various student quality measures at 127 engineering schools. Both the ACT composite scores and the SAT combined math/verbal scores of civil engineering students were lower than those of chemical, electrical, and mechanical engineering students.

For transportation engineering, these conditions result in three significant problems:

1) inadequate enrollment in civil engineering to provide the quantity of transportation engineers needed;
2) too few high quality students in civil engineering to provide for the best future leaders in the profession; and
3) an inadequate number of quality students to become the high quality educators needed for the future.

The problem to be solved is how can more quality students be attracted to civil engineering and become interested and educated in transportation engineering.
PROGRAM OF EDUCATION DESIRABLE

Transportation professionals and educators typically agree that the desirable education for a young man or woman who seeks a career in transportation engineering should begin early. The educational program should include the importance of service to people and society and the value of technology in solving many of the problems that will be encountered. Such emphasis should begin in the elementary grades and be clearly apparent in high school. Students aspiring to a transportation engineering career should also have a strong background in sociology, communication, computer utilization, and above all the basic sciences (i.e., mathematics, physics, and chemistry). These students should also enjoy such courses and develop an eagerness to continue to learn more.

For the B.S. degree, the programs of study most relevant to a transportation engineering career can usually be found in a civil engineering curriculum. The student should maintain a program at this level which covers a broad range of the courses and civil engineering disciplines available. It must emphasize the basic and engineering sciences pertinent to civil engineering (i.e., math, physics, materials, hydraulics, structural mechanics, etc.). It should also cultivate the value of a good understanding of service to people and communications with them.

The major purposes of a B.S. degree program for students seeking a career in civil engineering are to:

1) provide the basic and engineering sciences needed to recognize and solve new as well as current engineering problems;
2) develop oral and written communication skills; and
3) develop an eagerness to continue one’s education throughout life.

It is not a major purpose of a desirable B.S. program to train students only in how to do various activities associated with current practice. Only experience can do that in the ways the employers will want it done. The student’s program should enable the solving of new problems by creatively applying the scientific knowledge made available in the program of study and in continuing education.

ATTRACTION OF STUDENTS INTO CIVIL ENGINEERING

As already noted, the initial problem is to attract students into civil engineering. Of major importance, then, is to recognize the factors which attract young men and women to a particular career.

In 1986, a study and final report titled Career Guidance in Engineering was made by several students at Worcester Polytechnic Institute for the National Society of Professional Engineers (NSPE). This study was performed in cooperation with the Guidance Coordinator at NSPE. The study included an extensive literature review about the career decision-making process of individual students. Possible influential factors found include environment, childhood experience, abilities and interests, self-concept, image of a vocation, personality of the student, and maturity. The roles of counselors, teachers, parents, and business and industry were extensive but tended to be idealized. Attitudes of such individuals often, however, were found to mold a student’s perception of a particular career. Of perhaps most importance was the finding that no single method of obtaining career information is completely effective by itself.

The analysis of the results of a questionnaire survey sent to 55 of NSPE’s liaison societies on their career guidance activities provided some pertinent infor-
mation. A total of 31 completed questionnaires were returned. Personal interviews were then conducted with users of guidance materials: high school guidance counselors, math and science teachers, and upper level math and science students. The analysis of these data resulted in the following:

1) an overwhelming majority of those surveyed and interviewed believed that personal contact, as compared with written and audiovisual materials, is the most effective, single guidance medium;
2) a combination of all three, personal contact and written and audiovisual material, is ideal; and
3) the most important purpose of effective guidance material should be to provide a clear definition of engineering, its subdivisions (for civil, examples are structural and transportation engineering), and a clear and accurate description of the work engineers do.

The recommendation of the report is that the best guidance program is a mix of personal contact and written and audiovisual materials. Other effective alternate programs are a “mentor” or “shadowing” program or a summer job with professionals in the career of interest.

THEORIES OF CAREER CHOICES

The study noted in the previous paragraphs also reported on four basic theories of career choice by young men and women. One of these is the “trait factor” theory which matches an individual’s abilities and interests with the world’s vocational opportunities. This, of course, has developed into the vocational testing method.

A second theory widely accepted is the accident theory of career choice. This approach assumes “that circumstances beyond the control of the individual contribute significantly to the career choices made.”

A third theory with some acceptance is the self-concept theory to career counseling. In this theory, the individual’s self-concept is recognized as more clearly defined as one matures. Individuals also develop images of careers in the working world. The career decision is often dependent, then, on the similarity between an individual’s self-concept and the individual’s concept of each of several possible career interests.

A final basic theory of career choice is that people select their careers because they see potential for the satisfaction of their personal characteristics or goals.

In summary, it is apparent that many factors are involved in career choice. The major ones include the individual’s concept of his/her abilities and desires; the image of a career field as visualized by the young person; and the satisfaction one perceives from a career field. Other factors of importance are lifetime development opportunities, income potential, and the professional and social status of the career field.

Fundamental to effective career guidance are:

1) techniques which effectively inform a young person from the elementary grades through early years of college about the correct attributes and characteristics of each vocation;
2) techniques which correctly inform a young person of his or her abilities and needs and how they relate to each vocation;
3) the opportunities for self-development and professional growth within each vocation;
4) the personal income potential of each vocation; and
5) the professional and social status of each vocation.

DISCOURAGING ASPECTS OF CIVIL ENGINEERING

On the basis of the analysis in the preceding paragraphs, it is obvious that some discouraging characteristics exist in civil and transportation engineering which must be improved in order to attract students. Major characteristics subject to improvement are:

1) the image of the civil engineering and transportation engineering professions;
2) the average salaries of beginning civil/transportation engineers as compared to other engineering disciplines; and
3) the professional and social status of the civil/transportation engineering professional.

A NEW IMAGE OF THE CIVIL ENGINEERING PROFESSION

During 1987 and 1988, the American Society of Civil Engineers conducted a study of “Civil Engineering in the Twenty-first Century.” A major component of the study was a workshop on the subject at which over 100 leaders in the profession reviewed the history, studied the current problems, and predicted the future of civil engineering. One of the several areas of the profession reviewed was that of transportation engineering. One of the products of the workshop was a view of a new image of the civil engineering profession including transportation engineering.

Civil engineering has often been recognized to be the engine that drives society’s progress. Certainly from the days of the early pyramids, man’s achievements and welfare have been measured largely in terms of civil engineering accomplishments. It is reasonable to assume that the twenty-first century will see a continual demand for civil engineering types of services.

It is also probable that the focus of national attention in the United States for the next several decades will continue to place importance on improving the “quality of life.” This interest may also become of more concern in the second-, third-, and fourth-world nations.

What will civil engineers of the twenty-first century be doing? Civil engineering activities relate to people. Thus, as the world’s population continues to increase, there will be an increased demand for water, energy, waste management, transportation, and enclosed spaces—places where civil engineers have traditionally served in leadership roles.

Great opportunities for civil engineering activities will still occur in those regions of the world with large populations—China, Africa, India, and South America. Although financing will determine the speed of progress, the sheer magnitude of need will result in significant development.

In contrast, the developed countries such as the United States, Japan, and the European community, will continue to see new projects due to population shifts, increased population, increased urbanization, and technological progress. In addition, there will be an increasing and major emphasis on expanding and rehabilitating the deteriorating infrastructure.
The developed nations of the world already have tremendous investments in physical facilities, which are loosely termed infrastructure. As the infrastructure deteriorates with age, it must be restored; furthermore, the decisions regarding renovation in existing locations with expansion of these systems versus new construction in other locations will become more complex. The question of whether one should move people to the factory or much of the factory activity to the people will be studied in much larger scale—and with economic, environmental, political, and cultural effects involved in the decisions.

More and more social awareness of real costs and environmental issues will factor into project decisions, on both public and private work. Technical and economic solutions alone will not necessarily suffice; many decisions will require consideration and quantification of such factors as politics, environment and ecology, financing, legal and liability matters, and even international relations.

Above all, civil engineering work will have an international flavor, regardless of the location of given projects and engineering offices. Competition for services will often be on a global basis. Employees within a large firm will be international in both heritage and training. Local firms will often compete with international firms, even for local projects, and conversely, will have considerable business outside their geographical regions.

Thus, the future is bright in terms of volume of work—work of the type which civil engineers do. The civil engineer should not feel that some of this work, that is, maintenance and rehabilitation of present structures and systems, is degrading. It can be, and is, exciting and productive—and certainly will benefit from innovative and creative thinking in the development of new materials and methods of work. In the twenty-first century, it will be much more of a systems-oriented process, looking at broad implications and impacts, again an exciting opportunity.

As projects and project decisions become more complex, the tools with which civil engineers work will become more sophisticated. Obviously, the uses of computers will increase as user-friendly software and data bases evolve. In particular, risk/decision analysis methods will gain more application and artificial intelligence/expert systems applications will abound. CAD/CAE will be commonplace, but will have the greatest new use in the generation of more options at the planning stage of a project. Thus, the resources for continual CAD development and updating will continue well into the twenty-first century.

Considerable attention and capability will be centered around diagnostics of existing facilities. Non-destructive testing methods will be combined with sophisticated inspection techniques and computers to provide a necessary tool for the analysis of renovation needs and potentials and for structural safety and conformance to design and standards, both during construction and after.

The nature of site construction activities will change. Due to increased computer and sensing capabilities and the driving forces of safety, work force demographics, productivity, and increased use of construction, automation will develop. The use of construction robots will emerge for repetitious and dangerous operations. This automation in construction will, in turn, demand changes in design for optimization.

International communications will be commonplace. Data transmission will be done instantaneously, via satellite, between locations. Localized information will be available to remote offices. Staffs in vastly separate locations will be able
to view remote information from various sources simultaneously, working together through satellite communications to come to decisions. Even language translation capability will be commonly available.

The twenty-first century, however, will produce a significant change in a civil engineer's activities and the tools that will be used. The civil engineer will be more of a manager of information and knowledge than one who produces information. Handbook engineering will be a thing of the past. Civil engineers will become integrators and analyzers of data and will provide meaningful decision information. As such, they must have access to (and familiarity with) all the most sophisticated diagnostic, computational, and communications equipment.

There will be significantly different materials to work with, and these in turn will require new techniques to use. Concrete with high tensile strength, virtually frictionless skins, ultra-light weight, high strength materials and honeycombs, fatigue-proof metals, and high strength adhesives are but a few of those we may expect to see. New techniques, frequently automated, will be required. Engineers will also develop new methods for the unique environments of the oceans, space, and the arctic, which will allow a much greater use of these areas.

As the civil engineering practitioner's role shifts from technical concerns to data and knowledge management, so must the work environment. Integration of technical data with that from other disciplines will be critical. Thus, civil engineers will spend increasing portions of their time in developing and managing interface relationships with other professions. Lawyers, accountants, bankers, government representatives, insurance companies, and other non-scientific professions will have increasing inputs into civil engineering decisions along with input from testing agencies and other technical sources.

Civil engineers must face the challenge of integrating and assimilating diverse data from diverse sources to reach meaningful decisions. As such, they must place increased emphasis on their professional development since the profession will be constantly changing. More and better interrelationships between and among educators, researchers, and practitioners will be required to optimize the anticipated role of civil engineers as they provide solutions to new and expanded needs, in both old and new geographic areas and with improved quality, reliability, responsiveness, and economy.

Finally, civil engineers must be skilled communicators (oral, written, and computer). As the key professional in the key profession, civil engineers will be overall project managers with full authority and responsibility. They will need to be innovative. They will have to look at the whole system including the socio-political-economic-cultural aspects as well as the technical. They will be the advisors to the public and political leadership.

THE LOWER SALARY PROBLEM

In addition to the problem of the image of the civil/transportation engineer is the problem of beginning salaries. For many years, beginning salaries for new civil engineering graduates have been less than those obtained by graduates of other engineering disciplines. In recent years, this has been about $2,000 less annually than the next lowest engineering discipline and $4,000 to $6,000 less than the most popular engineering discipline.
This lower salary obviously does not attract students, especially the very capable students. Annual salary surveys of the engineering disciplines for a number of years, such as the NSPE Annual Salary Survey of Engineers, typically show that the lesser average salary for civil engineers exists throughout the nation in the early years of practice but tends to become equal or greater than the average of other engineering disciplines after about 15 years of practice—and stays ahead thereafter. Nevertheless, the lower beginning salary is an impediment to the recruitment of top quality students to civil engineering.

Perhaps if one could determine the reasons for the lower salary in the early years, one could do something to correct this impediment. It is the majority opinion of the members of the authoring committee of this report that one major reason is due to the absence of full competition for top quality graduates by the employers of new graduates. In other engineering professions, industry primarily is the employer. The most successful of these clearly recognize the value to them of the most capable graduates, and they are willing to pay more to obtain such a person, if competition demands it. And it usually requires such action.

For civil/transportation engineering, the initial employer is likely to be a governmental agency or a private enterprise organization performing consulting or contracting activity. Salary scales are most often set by averages of the recent past. Often, starting salaries offered are based on an established scale and all applicants are offered the same salary. The result is that this condition acts as a dampening force on all civil engineering beginning salaries. Because of the absence of full competitive forces by all employers for the most capable new graduates, the average salary paid is lower than for other major engineering disciplines.

THE LESS THAN OPTIMAL STATUS OF THE PROFESSION

Many civil engineers in government find that they not only have a lower beginning salary than other engineers, but they also find a less than desirable environment in which to work. Many find that sound technical solutions are frequently compromised by political decisions. They find wise, long-term plans are discarded for short-term benefits and the likelihood of heavy, long-term costs. They often find available resources are far less than required to do a good job. They frequently find that their advice and counsel on engineering matters are not followed—and sometimes not sought. Often their expected societal status as a leader in their community is non-existent and, if status is acceptable initially, it frequently deteriorates rather than improves even though excellent output from the individual and group has resulted. Although these conditions exist, the political atmosphere may not be the only problem. Too often these results occur because the incumbents in professional positions failed to establish top credibility with elected officials.

ATTRACTING STUDENTS TO THE CAREER

Emphasis has been placed in this report to this point on some of the major reasons why the profession has not attracted the quantity and quality of students needed to the civil/transportation engineering profession in recent years. The report has indicated the best methods of recruitment, the factors which attract students, and the factors which exist that discourage top quality students from
selecting civil/transportation engineering as a career. In order to attract top quality students, our profession needs an effective recruitment program and needs to eliminate, or at least negate, some of the factors which inhibit attraction. How can this best be done? The committee recommended the following actions.

ATTRACTING THE BEST TALENT

All civil engineering and transportation engineering professional and technical societies and all civil engineering/transportation engineering practitioners must develop and effectively utilize materials which enhance the image of the civil/transportation engineer. That image must be a positive one in tune with current and developing technologies. The profession must be seen as it truly is—challenging; providing an extremely important service to the quality of life, economy, and society; people serving; sensitive to the environment; utilizing the latest technologies; and providing a fine, enjoyable, and satisfying career.

The problem of low beginning salaries offered to young engineers needs to be aggressively attacked and resolved. Upgrading the image will help. As noted in this report, changing the salary policy in the recruitment of beginning civil engineers by some employers of new graduates would undoubtedly be very helpful. Civil and transportation professional societies and all current practitioners should promote the adoption of a policy by all employing agencies, especially those with large numbers of civil/transportation engineers, which acknowledges the great value to them of top quality new graduates. Employers should truly compete with each other and industry to hire the best graduates each year.

The environment in which engineers work, especially government, must be upgraded to recognize the reality that short-term benefits may not be wise reasons in decision-making, that inadequate resources are likely to result in continued inadequacy, that engineering analysis will usually result in wiser decisions than political expediency, and that the civil/transportation engineer must be recognized and rewarded as top level, high quality personnel should be—or they will not be retained.

Finally, our professional societies and all members of the civil/transportation engineering profession must aggressively recruit students to these professions. The recruiting technique that will be most rewarding in attracting the best talent will be individual/personal contact by members of the profession utilizing their experience together with materials professionally prepared for various levels of students.

Some materials should be directed at the general public, including elementary students, which inform them about civil/transportation engineering, create a positive image of the career, and develop in the young person an attractive vision of the profession.

Other materials should be for high school students. These should provide greater insight into what a transportation/traffic engineer does, what courses will serve their education best, and what they can do that will be of service to people. The materials must present the student with an attractive, positive image of such a professional.

Materials should also be directed at the high school senior and the beginning college student. These should present more specifics about the profession, the
activities in which a professional member may become involved, and what courses will be of greatest value.

Personal contact by members of the profession in support of the materials noted above will always result in more effective recruiting activity. Personal contact—individual contact—must be emphasized, for it is the most effective recruiting method available.

With good materials that inform the student about transportation engineering and individual contact to answer questions, provide additional promotive discussion about the profession, and discuss personal experiences that have been valuable and satisfying, individual recruitment of top quality students over many months, perhaps even years, is likely to be successful. The professional might also utilize the "shadow" technique to further educate the potential recruit about the profession. Let the potential recruit be with you as you perform your transportation/traffic engineering activities for a day or so at a time to provide the recruit with a real taste of the profession.

Other techniques are, of course, needed to attract some potential students to transportation/traffic engineering; summer traffic engineering jobs for high school and college students; student scholarships or fellowships; and participation in co-op programs with the student’s university.

RECOMMENDATIONS

To provide solutions to the problem of too few transportation engineers being available to meet the needs of today, it is recommended that our professional societies develop a comprehensive recruitment program directed to students who could become quality professionals. This program should consist of:

1) develop materials (written and audiovisual) which are directed to the public and to students in elementary school, high school, and college, and which enhance the image of the transportation engineer;
2) promote within the profession and with employers the importance of recognizing the value of high quality professional transportation engineering and that enhancement of quality is heavily dependent on the quality of the personnel; encourage and promote adoption of policies which provide for effectively competing for the best professionals, especially relative to salaries and work environment;
3) develop separate materials (written and audiovisual) for two groups of people that will (a) inform the public and school children about transportation engineering (and also inform the teachers and counselors) and (b) seek to recruit high school and college students to a career in transportation engineering (and also inform teachers and counselors);
4) develop among practitioners a large number of professionals who will agree to provide personal contact with elementary, high school, and college students to enhance the distribution of these materials and who will recruit individual students for the profession; for individual recruitment, these professionals would utilize such techniques as regular periodic contact for discussion, "shadowing," summer jobs, co-op programs, and fellowship or scholarship assistance.
Several effective groups for this activity should be pertinent professional society student chapters and their other organized professional groups throughout the nation.

A successful recruitment program, and it will be successful if members of the profession provide the energy and resources to effectively conduct it, will provide significant improvement in two of the current major problems of the profession: too few transportation engineers graduating each year and few top quality students seeking careers in transportation engineering.

CONCLUSION

If transportation engineering continues to be successful in the twenty-first century as a profession, it will be because we are able to attract the brightest young people and to provide individuals who can adapt to the rapid changes that are foreseen and unforeseen. With proper education, motivation, and research, the tools will be available for these new professionals to address the exciting challenges of the future. The net result will be transportation engineers who are masters of their destinies and who fulfill a role that addresses the needs of society at the highest level.

To be successful in developing a sufficient number of such transportation engineers for the twenty-first century will require the dedicated service of the pertinent professional societies and the community of practitioners. In reality, that challenge is now before the profession.
REFERENCES
1. "Grade Points of Students Leaving Freshman Engineering at Purdue University," unpublished periodic inter-office memorandum from the head of Freshman Engineering to heads of all Schools of Engineering at Purdue University, West Lafayette, Indiana, 1980-1988.


5. "Civil Engineering in the twenty-first Century," American Society of Civil Engineers (ASCE), a draft summary of portions of the discussion, comments, and materials presented at a workshop on the topic in November 1987 as interpreted by Harold L. Michael and many others in attendance.
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### TABLE 2

ENGINEERING DEGREES AWARDED TO FOREIGN NATIONALS, BY LEVEL

1986

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1987

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*Includes professional engineer degrees