ON PROFESSIONAL DEGREE REQUIREMENT FOR CIVIL ENGINEERING PRACTICE

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I. Introduction

In May 1998, ASCE NEWS announced that the Board of Direction "approved a resolution endorsing the master's degree as the first professional degree for the practice of civil engineering." The July 1998 ASCE NEWS clarified the earlier article by quoting the definition of the "first professional degree" used by the U.S. Department of Education. It is defined as "a degree that signifies both completion of the academic requirements for beginning practice in a given profession and a level of professional skill beyond that normally required for a bachelor's degree." Such a degree is generally required for dentists, physicians, pharmacists, lawyers, theologians, and architects. It is usually based on a total of at least six academic years of work. Arguments that have advanced for considering such a professional degree for civil engineering practice include:

- The bachelor's degree is no longer adequate preparation for civil engineering practice.
- This change would improve the professional stature of civil engineers and thus improve the compensation of practitioners.
- It would provide a clear distinction between civil engineering graduates and technicians.

The same July 1998 article reported that the ASCE Board of Direction is contemplating promotion of a policy being prepared by the Educational Activities Committee. Also, the Board may decide to seek support from such organizations as the Accreditation Board of Engineering and Technology, the National Society of Professional Engineers, and the National Council of Examiners for Engineering and Surveying. Indeed, ASCE may become a leader in this effort. Recently, the ASCE Board of Direction approved a policy statement that is given in the Appendix.

The authors are in favor of (1) strengthening the education of civil engineers, (2) meeting the employment needs of industry and government, and (3) increasing the professional stature of practitioners. Furthermore, there are many demands on engineering education at this time, suggesting that it may be timely to re-organize the curriculum from scratch. Some of those demands relate to calls for a curriculum that would:

- integrate skills in communication, teamwork, and leadership into technical courses,
- establish a solid base in mathematics and science,
- expose students to economics and socio-political implications of engineering works,
- use mechanics and risk-based decision analysis as common threads,
- provide a broad-based undergraduate education,
- present specialized education at the upper undergraduate and graduate levels, and
- emphasize quality rather than quantity in the education of future civil engineers.

Meeting all these perceived needs would seem to provide a strong argument for a five-year curriculum.

On the other hand, there seem to be a number of issues that must be carefully considered before instituting such a sweeping change as requiring a professional degree for civil engineering practice. Of particular interest are the following issues:

- Under current standards, many BS recipients would not qualify for admission to a master's program. Would the entrance requirements be lowered so that the same number of civil engineers would enter the job market? In other words, would master's admission standards be lowered to accommodate essentially all current BS recipients? If not, then would the profession be willing to accept the situation of a large number of students completing a four-year pre-engineering program, then being denied a professional engineering degree?
- Would employers continue to hire BS degree holders even though they would not be eligible for P.E. licenses?
- At present, there is considerable flexibility in master's degree programs with each institution capitalizing on its own particular strength. Would similar flexibility be feasible in accredited master's programs, or would accreditation standards force uniformity on programs and thus eliminate small, specialized master's programs, even if they are of excellent quality?
- In the past, accreditation standards have been understood to emphasize with design. Would this accreditation change pose particular problems to graduate programs with an emphasis on analysis and behavior, rather than design?

These and other topics are discussed in the paper. The authors try to stimulate interest and the audience will be encouraged to participate in the discussion.

II. Some Issues Which Must Be Addressed

More than a hundred years ago, engineers needed four years of college studies to become qualified. Today, there are more technical materials (e.g., risk analysis of various civil engineering systems, general computer analysis, information technology, and study of intelligent structural and transportation systems) to cover in all engineering disciplines. All this is in addition to the non-technical needs already mentioned: integration of communication, teamwork, and leadership into technical courses, exposing students to economics and socio-political implications of their engineering works, and providing a broad-based undergraduate education. The combination of all these demands certainly provides a strong argument for more education for future engineers. At the same time, at least three states have mandated 120 as an upper limit for the number of semester-hours required for any bachelor's degree. More states are now under pressure from parents and other citizens to follow this trend.

Engineering graduates are often indignant when the university president or provost does not count the College of Engineering as a professional school. In fact, though, these university administrative viewpoints are supported by the statement from the U.S. Department of Education quoted above, since engineers commonly enter the job market with only a bachelor's degree. From this point of view, a four-year bachelor's program in engineering is no more professional than one in history or English.

After a detailed study John Alexander[1] concluded that there is no shortage in the supply of civil engineers. He proposed that fewer, but better quality civil engineers were needed. Upgrading the educational requirements for civil engineers might lead to their becoming viewed as true professionals in the eyes of the general public, and to corresponding increases in their compensation levels. However, it must be kept in mind that Alexander's conclusion that few civil engineers are needed is contrary to that of many other educational and engineering analysts, so the issue should be studied carefully. It surely is true that a reduction in the number of civil engineers, if accompanied by no other changes, would lead to increased competition to hire those individuals, and that this would lead to increases in compensation and prestige. On the other hand, there may be several difficulties with this procedure. For example, if the technical and intellectual ability required for the civil engineering degree were not substantially increased, then it would seem that the increased salaries and prestige would lead to extreme political and public pressure to increase the availability of openings for civil engineering students. Of course, the requirement of a rigorous post-baccalaureate degree program could serve to limit the numbers, but this is also dependent on the actions of employers. In particular, if employers do not agree as to the need for the advanced education, then they might choose to rely much more heavily on graduates of engineering technology programs. This could reduce the demand for civil engineers, possibly as much as or more than the reduction in the supply. On the other hand, of course, employers could conclude that there is a need for the advanced education, and then this decreased demand for civil engineers would not develop. The point is that it is difficult to predict which situation would occur, and that the outcome depends on the choices of employers. Overall, it seems that requiring more education for entry into the profession must be based only on the demands of the workplace, not on a desire to reduce the numbers.

In recent years the demarcation between civil engineers and technologists has become fuzzy, since engineering and engineering technology programs both require four years of education. A requirement for a post-baccalaureate professional degree for civil engineering practice would provide a clear distinction between the civil engineers and the engineering technology graduates. As mentioned above, though, this may not automatically increase the demand for civil engineers. The demand for these professional engineers with post-baccalaureate education will depend on the decisions of employers. The civil engineers could essentially lose the job market of employers who conclude that a four-year education is adequate to their needs.

Another issue that should be considered in assessing the adequacy or inadequacy of the current system is the level of preparation of the incoming students. In particular, if the students graduating from high school now are better educated than those of one hundred years ago, then one must also presume that current graduates of a four-year curriculum are at a very different level that those of the past. The authors can certainly attest to the occurrence of major changes in much less than one hundred years. Possibly the most dramatic changes have been in mathematics. First there was the movement to the high-school level of introductory calculus, which was a second-year university course in the 1950s. Related to, but not limited to, mathematics is the computer knowledge of current students beginning a college program. Computer applications did not even exist in the typical engineering program in the 1950s, and some entering freshmen are very able in this area -- probably better equipped than some of their professors. They can obtain information from the Internet and use many kinds of software, some

of which can be used as substitutes for traditional mathematical analysis. However, the evidence may not be entirely in support of increased capability. For example, some students entering advanced level courses in engineering seem to be deficient in some traditional aspects of calculus, such as integration by parts. Indeed, it is possible that this lack in their preparation may be partially due to reliance on computer solutions. Also, it seems that there may be more students asking only for numerical examples, rather than trying to understand the underlying principles and how to apply them. Possibly they have missed something of the logic or rationale of traditional analysis.

Overall, it is not easy to reach any general conclusion on the issue of the effect of student preparation. Surely there are a number of ways in which current entering freshmen are better prepared than were those of the past. There may be other ways in which current juniors may have not gained all of the techniques, which were formerly emphasized during the first two years of the program. The real issue, though, is not the level of preparation of the entering students, but rather the amount of education, which is needed to reach the appropriate level for the graduates. If there is agreement on the level needed for entry into the profession, then one can use this along with an assessment of entering students to design a curriculum that meets the needs. The fact that both the entering and exit levels are higher than in the past gives inconclusive evidence about the need for an increase in the engineering educational program.

Another set of practical difficulties which should be considered are the problems which will arise if a large number of students enroll in pre-engineering programs, then are denied admission into the professional master's program because they do not meet the requirements for a graduate degree. At least initially it should be expected that this might lead to considerable public and political pressure to lower the standards for admission to graduate study because of concern for the plight of an individual who faces denial of an engineering degree after spending four successful years in pre-engineering. In addition, the fact that many departments are funded according to the number of enrolled students could produce another strong incentive to lower the graduate standards in order to keep the number of students high, in both the pre-engineering and graduate programs. It seems, though, that such lowering of graduate standards would defeat the goal of producing better civil engineers, and it surely would be contrary to the more controversial goal advocated by Alexander of producing fewer civil engineers.

III. A Possible Alternative

All the questions and issues raised above have been based on the assumption that the future civil engineering educational program would be much like that of the present, except for a renaming of the BS program as pre-engineering and designation of the master's degree as the first professional degree. This, though, is not the only model that might be adopted. In fact, this model is quite different from that used in medicine, law, and other professions which have been cited as examples of the shortcomings of engineering education. In many (if not all) universities it is not possible for the undergraduate to major in pre-medicine or pre-law. Rather, the student chooses a baccalaureate major based on personal interest, and uses elective hours within that program to take some pre-professional courses. At the completion of the four-year undergraduate program the individual might have a BA in history or economics, for example, as

well as having the necessary prerequisite courses for application to the professional school. Perhaps engineering also should consider this model as a possibility.

What would be the consequences of moving essentially all engineering courses to the graduate level and having the student pursue a bachelor's degree in any field of choice before applying to an engineering school? Clearly this would allow much greater emphasis on the humanities and social science topics which are often cited as being deficient in current engineering curricula. One would expect that there would also be greater emphasis on both written and oral communication, thereby addressing another noted problem in the present situation. Another consequence of such changes would surely be the unquestioned recognition of engineering as a profession, since this is the educational model used by other professions. There can be little doubt that this educational program would produce engineers who would be better equipped to deal with issues related to the societal implications of engineering.

Engineering programs, of course, would change drastically under the suggested plan. Presumably, essentially all courses taken within the engineering program would be technical in nature, since the student would already have received a liberal undergraduate education. Even at this, though, it is not clear how many years would be required for the first engineering degree. It seems that the number of required technical courses within current BS engineering program would be equivalent to about two years of full-time study. This, though, ignores the problems of providing the proper sequence for the courses, as well as current demands for additional advanced level material beyond what is now required for the BS. It seems unlikely that the program of choice would be one requiring a total of six years (four as an undergraduate, two as an engineering student) simply to achieve the same technical level as a BS graduate under the current system. It seems more likely that an acceptable professional post-baccalaureate engineering program would require three to four years, thus bringing the student to a technical level at least equivalent to that of a current MS student. This combination of a liberal bachelor's education and a master's level technical proficiency would, thus, require seven to eight years.

It seems, though, that careful study should be given to the economic and social consequences of going to a system that requires seven or eight years to reach entry-level employment in engineering. Traditionally, engineering has been one of the fields most compatible with moving quickly from high-school graduation to entry into the job market with skills in significant demand. This has provided a very attractive choice for students from families with limited financial resources. Would the proposed changes lead to a screening of potential engineers, not on the basis of ability, but on the basis of having the financial resources to spend a longer time in school? Would this be positive for the profession or society? Provision of adequate financial assistance for engineering programs, of course, could offset this effect, but what would be the source of these funds? Under the current system, funding for graduate student stipends largely comes from research projects. It is not clear that the proposed changes would increase the availability of funds from this source, since most of the professional engineering program would be devoted to course work rather than to research. Additional current stipend funding comes from hiring graduate students as teaching assistants for undergraduate courses. If anything, it seems possible that this might be more difficult under the change, since all the engineering

students would be graduate/professional students. This is an issue needing additional study and formulation of creative solutions.

Law school and medical school are certainly two examples of post-baccalaureate professional programs which seem to function well without significant financial assistance for the students. It seems that the standard model in these fields is for the student to borrow heavily in order to complete the educational program, then enter professional practice with significant personal debt. This, obviously, is another possibility that engineers could follow. It is our perception that this would not appeal to many of our current engineering students, but this may be primarily a reflection of students' expectations based on observations of current practice. That is, it might be quite feasible for the students' views to shift gradually over the coming years, so that such personal debt would be regarded as quite natural and not a major deterrent to entering an engineering program. It does seem clear, though, that a student is very unlikely to be willing to take on such educational loans in pursuit of a professional degree unless there is a high expectation of a beginning professional salary which is adequate for timely repayment of the debt.

Thus, the issue again turns toward the employers. How much would employers be willing to pay to hire a graduate who had a combination of a four-year liberal bachelor's education and a master's level technical proficiency? How many of their current engineering positions would they fill with these professionals, and how many would they fill with persons having non-professional degrees in engineering technology?

IV. Concluding Remarks

The arguments for more education for civil engineers have been fairly widely discussed in recent years. The proposed list of needs for a better professional education has been very broad, including more courses in humanities, social science, and advanced technical subjects, as well as further development of written and oral communication skills. The educational model being most discussed seems to be based on the current system, but with the BS degree being redefined as being pre-professional, and the master's degree being accredited as the necessity for entry into professional practice. This paper has largely focused on the possible difficulties associated with such a program. These include pressures for lowered standards for admission into master's programs and pressures for uniformity among master's programs. It is thought that yielding to either of these pressures would diminish, rather than improve, the educational system. Associated with the issue of admission standards are questions related to the future facing the possibly large number of individuals who might complete a four-year BS program in pre-professional engineering, then find themselves unable to pass the standard for admission into the professional master's program. The authors also question the extent to which the engineering job market will demand the proposed professional engineers, and the extent to which it may turn to hiring non-professional BS graduates, from either pre-engineering or engineering technology programs.

Some pros and cons of doing away with undergraduate engineering programs and requiring a liberal arts bachelor's degree for entry into professional schools of engineering have been

examined in this paper. This program would probably extend the path from high school to profession to as much as seven or eight years, which is significantly more than in the alternative resembling the current master's degree. Again, there are many ramifications, including methods of financing and societal acceptance of this model as an attractive career path, particularly for students from families with low to moderate income.

A key question in all of these considerations seems to be the needs of the civil engineering employer. It is well known that many civil engineering employers now require a master's degree for entry level employees in some specialties. In fact, this has been used as one of the arguments for moving to a requirement that this be true for all civil engineers. On the other hand, a majority of current civil engineers do now find employment armed only with a BS degree. It is unclear how this majority of civil engineering employers would react to the proposed educational changes. It seems that a crucial step in designing a more satisfactory system is finding some answer to these employment questions. The educational system is surely capable of adapting to produce engineers with the skills that are needed in the marketplace. In fact, it can be argued that that is precisely what has happened with the growth of non-research professional master's programs in recent decades. The educational system, though, cannot answer the question of how employers will react to a change which is made without adequate consideration of their needs.

In summary, a number of issues related to the implementation of a post-baccalaureate professional degree in civil engineering have been raised. It is timely to address these issues in a constructive manner during the next few years prior to the implementation of any sweeping change.

V. Acknowledgment

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Reference

1. Alexander, J., (1990), "The Civil Engineering Shortage: Reality or Myth?" Education and Continuing Development for the Civil Engineer, 17-20 April 1990, pp. 463-468.

APPENDIX: Policy Statement Approved by the ASCE Board of Direction in October 1998

The American Society of Civil Engineers (ASCE) supports the concept of the Master's degree as the First Professional Degree for the practice of civil engineering at a professional level.

ASCE encourages institutions of higher education, government units, employers of civil engineers, and other appropriate organizations to endorse, support, and promote the concept of mandatory post-baccalaureate education for the practice of civil engineering at a professional level. The implementation of this effort should occur through establishing appropriate curricula in the formal education experience, appropriate recognition and compensation in the workplace, and congruent standards for licensure.