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National Impact of Foreign-Born Engineers



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NATIONAL IMPACT OF FOREIGN BORN ENGINEERS

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Introduction and Summary
by
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The TRB Committee on Transportation Education and Training sponsored a session at the 1989 Annual Meeting of the TRB dealing with Foreign Engineers: Implications for Transportation Engineering. The session started with a presentation summarizing the findings of the National Academy of Engineering report, "Foreign and Foreign Born Engineers in the United States."

The remainder of the session focused more sharply on the implications for transportation engineering with comments by panelists representing viewpoints from segments of the transportation community including academic institutions, transportation consultants, public sector, and the transportation industry.

The presentation on the NAE report was made by Dr. Alan Fechter, Executive Director of the Office of Scientific and Engineering Personnel. The panel was composed of:

Dr. Lester Hoel, Chairman of the Department of Civil Engineering at the University of Virginia, who discussed the viewpoint of the academic institutions.

Dr. Walter Kraft, Senior Vice President of the firm of Edwards and Kelcey, who discussed the viewpoint of the transportation consultants.

Mr. George Gray, District Deputy Director of CALTRANS District 4 in San Francisco, who discussed the viewpoint of the public sector.

Mr. Michael Rougas, Assistant Vice President for Research of the Research and Test Department of the Association of American Railroads, who discussed the viewpoint of the transportation industry.

NAE Report

The impact of foreign born engineers on many aspects of our society, engineering profession, universities, other components of the economy and our culture was of sufficient interest that the National Academy of Engineering requested that the Office of Scientific and Engineering Personnel undertake a study of the issues associated with the phenomenon.

Dr. Fechter divided his presentation by first discussing the findings of the NAE report, followed by the issues these findings generated, and ending with the conclusions based on the findings and issues.

The report contained three major findings as follows:

The proportion of foreign born engineers in the U.S. work force has been increasing such that over the ten-year period 1972-82, the percentage went from 8% to about 18%.

An even more dramatic increase took place in the academic sector with the proportion of engineering faculty who were foreign born rising from 10% to about 50% between 1975 and 1985.

The largest proportion of foreign born engineering students, as well as in the work force, in the U.S. are from India and the Middle and Far Eastern sectors of the world.

The impacts of these findings were then examined.

The question of whether these foreign born engineers were needed for the U.S. economy was unequivocally answered in the affirmative. Without these engineers in the work force and

in graduate schools, we would have a very difficult time achieving national goals.

Another question dealt with the effect on engineering education since the presence of the foreign born in faculty ranks is so pervasive. Three concerns were raised, including (1) effect of language barriers, (2) effect on under-represented groups in engineering, i.e., women and minorities, because of different cultural attitudes of the foreign born, and (3) effect on the character of engineering education. These were difficult issues to address. There was a general consensus regarding the first concern in that particularly the foreign born teaching assistants do have adequate written and oral communication skills. However, with respect to the two other concerns regarding effects on under-represented groups in engineering and on the character of engineering education, it was difficult to arrive at a consensus, with little evidence available to support or to refute the allegations. Therefore, these concerns were classified as unresolved issues.

Another question dealt with whether it is a wise policy to subsidize the education of foreign born students. It was also unequivocally answered very positively "yes" since a large fraction of these students stay in the U.S. and contribute to its development. In addition, many of these students have had their education subsidized by the rest of the world through undergraduate education.

Final questions dealt with whether foreign born engineers displace Americans in the work force and in graduate schools and whether their presence has a depressing effect on wages. The response to both of these issues was negative. Although there was no evidence to support any significant difference in salaries of foreign born and American engineers in the academic or industrial sectors, foreign born graduate students apparently can survive significantly better than their American counterparts with the level of stipends provided by most academic institutions.

Based on the findings and concomitant issues, the NAE report contained the following recommendations:

1. It is essential that no restrictive policy be adopted to reduce the number of foreign born engineers from entering the U.S.
2. It is essential to make full-time graduate study in engineering more attractive to American students by providing adequate stipends.
3. It is essential that universities accept full responsibility that new faculty and teaching assistants have adequate proficiency with the English language before allowing them in the classroom.
4. It is essential to improve dramatically pre-college mathematics and science education in the U.S. as a means of increasing the pool of potential engineering students.

5. It is essential to develop more quantitative data to evaluate whether any differences exist in teaching effectiveness and attitudes towards female and minority students between American faculty and teaching assistants and their foreign born counterparts.
6. It is essential to determine what impact, if any, foreign born faculty have on the quality and character of engineering education.

University Focus

Dr. Hoel's remarks focused on the perspective of the university. In this regard, he posed pertinent questions which were responded to comprehensively.

A brief summary of the questions and answers follows:

Question No. 1 - "Why are we seeing so many foreign born students in our engineering programs?"

Answer - The nature of the profession of engineering is such that it can be entered within a shorter period of time than other professional programs, and it is perceived as a field which provides respect and social and economic rewards.

Question No. 2 - "What is the implication for our engineering programs?"

Answer - Deficiencies in communication skills and different cultural backgrounds represent two major problems in the education of foreign born students. These same problems can be significant with respect to using foreign born graduate students as teaching assistants in the education of undergraduate students.

Question No. 3 - "Why are there so many foreign born professors at our universities?"

Answer - University appointments are perceived as prestigious positions and the requirements for advancement are consistent with the attributes of the foreign born with respect to research and scholarly achievements.

Question No. 4 - "Is there a problem and, if so, what should we do about it?"

Answer - Yes, there is a problem, and our system of professional education in transportation can be strengthened if the following policies or actions would be adopted or taken:

1. To attract a larger number of U.S. students to pursue graduate studies, a greater salary differential should be provided for those who earn advanced degrees.
2. To attract a larger number of U.S. students to careers in teaching, adequate financial support should be provided.
3. Adequate background should be required in communication skills and an understanding of the socio-economic environment in the U.S.

4. Greater emphasis should be placed on teaching effectiveness in hiring and advancement policies.
5. The image of engineering as a profession should be enhanced.

Consulting Engineering Focus

Dr. Kraft's remarks focused on the perspective of the consulting engineering firm, and his comments addressed five questions as follows:

Question No. 1 - "What is a foreign engineer?"

Answer - For the purpose of Dr. Kraft's discussion, a foreign engineer was defined as a person who was not born or educated in the U.S.

Question No. 2 - "How have consultants used foreign engineers?"

Answer - Two positive experiences can be cited: (1) U.S. consultants who are engaged in foreign projects as a prime or subcontractor hire local engineers, and (2) foreign engineers employed in the U.S. help a firm meet its affirmative action program. Unfortunately, some foreign engineers have been improperly treated by U.S. firms by providing substandard wages and poor working conditions.

Question No. 3 - "How is the foreign engineer different than the U.S. born engineer?"

Answer - Six differences were identified, including: (1) consideration of whether an individual is legally employable and for what period of time; (2) cultural and religious differences may require considerations of different holidays, restrictive diets for food catering services, religious restrictions affecting working hours, and the need to provide orientation about U.S. culture and how it affects project development and acceptance; (3) work ethic can be described in terms of dedication, loyalty, and hard working; (4) work experience; (5) communication skill deficiencies; and (6) engineering expertise can be described as comparable to their U.S. counterparts.

Question No. 4 - "What is the anticipated future supply of U.S. born engineers?"

Answer - A shortage is anticipated for the foreseeable future.

Question No. 5 - "What types of engineers are needed in the future?"

Answer - Regardless of whether engineers are U.S. or foreign born, they should possess good technical and communication skills and pertinent experience. Good communication skills are of paramount importance for both U.S. and foreign born engineers, and it should be developed by daily applications during the academic year.

Public Sector Focus

Mr. Gray's remarks focused on the perspective of the public sector, and he stressed the problems encountered by CALTRANS as a major employer of graduates from a variety of universities.

CALTRANS hired 690 entry level engineers in 1988 with about one-half being foreign educated or foreign born. Over the next several years it is expected that between 300 and 400 entry level engineers will be hired each year, and it is expected that a high percentage will be foreign born.

The foreign born engineers come from a variety of countries and the greatest majority of them were educated in U.S. universities. This diversity of ethnicity illustrates why possession of communication skills in English is so critical as it provides a common language not only between U.S. and foreign born engineers but also between foreign born engineers.

Foreign born engineers characteristically have technical competence and positive job attitudes.

State DOT's throughout the nation are in a transitional phase in which foreign born engineers may be playing a key role. To illustrate the characteristics of this transition, Mr. Gray used as a microcosm the U.S. CALTRANS District 4 in San Francisco where substantial changes will take place including:

An emphasis on rehabilitating the existing infrastructure rather than providing new facilities.

30% of the 1985 work force of engineers will be replaced by 1990.

50% of the 1985 managerial staff will retire by 1990 to be replaced by current middle-management engineers.

A recent study revealed that there are five primary obstacles to a smooth transition including:

1. The large number of engineers who will retire, about 200 statewide per year, over the next decade while it is expected that enrollment in civil engineering programs will decline.
2. The instability of the budgeting process to provide an orderly recruitment of replacements.
3. The difficulty in providing sufficiently challenging activities to recruit and retain well-qualified individuals.
4. The paucity of middle-management ranks to advance into top managerial staff positions.
5. The social and cultural differences between the younger and older generations which are exasperated by the large number of foreign born engineers in the work force.

Cultural differences between native born and foreign born engineers manifest themselves in a variety of ways including:

In many foreign cultures the engineer is considered to be a theoretician who is divorced from field activities and the evaluation of alternative impacts.

The correlation of age with wisdom and competency.

Family responsibilities transcending professional obligations.

The rejection, as equals, of members of the opposite sex and ethnical minorities.

Deficiencies in communicating skills.

Industry Focus

Mr. Rougas' remarks focused on the perspective of railroad engineering as a microcosm of the transportation industry. The needs of the railroad industry for engineers fall into three categories as follows:

1. Research - Even though much of railroad research is carried out by the Association of American Railroads, major railroads do have research departments.
2. Office Engineers - From various engineering disciplines involved in analysis and design activities.
3. Field Supervision - Requiring the ability to interact with a highly unionized work force. In addition to requisite technical skills, communication skills are of prime importance.

In each of the categories, foreign born engineers have performed well.

Audience Contributions

After the panelists completed their comments, discussion was initiated, and, unquestionably, the audience contributed significantly to the success of the session. Although the audience's comments mainly reinforced those made by the participants, other considerations were identified, including:

1. The great goodwill and economic benefits to the U.S. that are derived from having foreign born engineers who return to their countries after working or being educated in the U.S.
2. The need to provide a greater differential in compensation between recipients of bachelor and advanced degrees in order to attract more American students to graduate study.
3. The need to consider a five-year program for educating engineers. However, the point that was made was not the traditional debate that has been going on for many years about the five-year professional degree being required for technical competency, but that deficiencies exist in the process such that engineers are not being broadly enough educated embodying the concepts of humanism.

In addition, the importance of communication skills was reiterated by members of the audience and discussion led to a variety of suggestions to help overcome these deficiencies including:

1. The need for greater awareness and attention to the problem by the Engineering Societies. One way in which this can be manifested is through ABET accreditation units.
2. The need for foreign born students to associate with Americans to a greater extent outside of the classroom or laboratory. This would force them to use the English language rather than their native language by gravitating towards their own people.

3. The need to make communications an everyday part of the learning experience. It is necessary to use various techniques in both the universities and the work place in developing improved communication skills for primarily the foreign born engineers.
4. The need for state professional engineering boards to require English proficiency as part of the evaluation process.
5. The need to emphasize the role of communications in averting engineering and scientific disasters.

Summary of the Report:
Foreign and Foreign-born Engineers in the United States
by
Alan Fechter
National Academy of Engineering

I am delighted to be here at the Annual Meeting of the Transportation Research Board with this distinguished group of transportation experts to talk about foreign and foreign-born engineers, a subject that involves engineering personnel who work in transportation areas, but which goes much beyond these personnel in terms of its implications. I will try to summarize this report, but there may be points at which my views will creep in. When that happens, I will certainly try to tell you. Of course, my views do not necessarily represent the views of the Committee or the National Academy of Engineering or the National Research Council of which the Office of Scientific and Engineering Personnel is a part.

The study was commissioned because of the rising concern about the growing prominence of foreign personnel both in our engineering work force and in our engineering educational system, particularly in the graduate schools. What the Academy of Engineering asked the Committee to do was (1) to develop all of the relevant issues that might be appropriate to that growing prominence, (2) to assess those issues as best it could, and (3) where possible, to arrive at conclusions about whether this is good or bad for engineering and for the country. The Committee commissioned seven papers, which were presented at a workshop. It gathered every statistic it could find that related to the subject. Finally, it met several times to review the evidence, to review the papers, to review the discussion that took place at the workshop, and to try to develop a report through which its findings could be disseminated.

I am going to talk about the findings briefly, move from the findings to the issues these findings raised, and then turn to the conclusions the Committee reached based on these findings and their deliberation on these issues and to some of the conclusions they didn't reach because they couldn't. And again, I'm highlighting the report. The report contains lots of information so what I present is clearly my perception of what I think are the important findings and recommendations.

There are three major findings. The first was that the proportion of foreign-born engineers (not necessarily foreign citizens, but foreign-born engineers, including both foreign citizens and naturalized American citizens) in the United States work force has been increasing. We were able to find data for the period 1972 and 1982 which described comprehensively the engineering work force in the United States. Thus, over that period, we were able to track the growth. The prevalence of these foreign-born engineers went from roughly 8% to roughly 18% over that period. The largest increase that took place among the foreign born was the increase in the naturalized citizens. So what we are experiencing is no different from what we have experienced in the past; immigration of foreigners to this country in areas of employment opportunity.

The second finding, and perhaps even more dramatic, is that the increase has occurred disproportionately in the academic sector. This finding shows that, if you look at all engineering faculty, the proportion who were foreign or foreign born, rose between 1975 and 1985 from 10% to almost 50%. If you focus on those at the assistant professor rank, who are 35 or younger, the proportion went from about 10% to over 50%. In one year, the proportion went as high as 55%. So there has been a very marked and dramatic increase in foreign presence among our engineering faculty.

Finally and also importantly as we'll see later on, the largest numbers come from areas of the world that include the Far and Middle East and India. This is a contrast to earlier immigrations which came from Western Europe and Eastern Europe for political reasons. We don't know whether this recent migration is politically motivated or is motivated simply by differential opportunities; that's still an open question.

Those were the findings. What are the issues that are raised by these findings? I presume those of you who are here are interested in what civil engineering looks like in all of this. If you look at foreigners as a proportion of all undergraduate engineering students in the United States in 1985, the number is 13%. And that is the largest proportion at the undergraduate level in the disciplines of engineering that are being reported. Industrial, electrical, materials, mechanical, chemical, aerospace, nuclear and others are all much below that. The next largest fraction is in industrial engineering where it is 10%.

The other finding that I think is of interest is at the post-doctorate level. Two-thirds of the postdocs in engineering today are foreign born. And among those who are civil, about 60% are foreign born and that's lower than the average. So there's a sense of the civil being strongly concentrated at the undergraduate level as opposed to the graduate level.

Let me talk about the issues. Starting with the question of, "What does this mean for our economy?" The first question the Committee addressed was, "Do we need these foreign-born engineers?" The answer was an unambiguous yes. Without these foreign-born engineers, both in our work force and in our graduate schools, we would have a very difficult time meeting national goals in both the academic and the industrial work force. One of the papers commissioned for the study, written by Peter Canon, surveyed about 20 directors of major R&D labs in this country, who reported that without these foreign-born engineers, important work would not get done, and they are growing in relative importance. By implication, of course, these findings suggest that they are not replacing American engineers in these functions.

A corollary to the presence of foreign-born engineers in this country is the issue of the absence of American students. The Committee very clearly takes the position that the foreign born presence in this country is not the problem. The problem is the absence of American students interested in taking particularly engineering work at the graduate level. This is what needs to be focused on.

The quality of those foreign-born engineers, both in the work force and in our graduate schools, is very high. Thus, the quality of our work force is not being undermined as a result of their being present. So, they are needed and they fill an important role, and given their quality, they fill it very well.

However, like any new group of immigrants coming to this country, problems do arise as they attempt to integrate into our society. The Committee was very concerned about those problems and tried to address them in a very direct, straightforward way. It was difficult and there was a lot of deliberation in committee meetings to try to arrive at the cultural implications of their arrival in this country.

The question that was of concern was, "What is their effect, particularly on engineering education, since their prominence in academia is so pronounced?" Three levels of concern were raised and addressed by the Committee. The first,

of course, is possible language barriers. There may be a qualitative problem in the sense that foreign teaching assistants or faculty may not be able to communicate well with student bodies because of the fact that English is a foreign language to them. With respect to the language barrier, the Committee said that it could be a problem.

The second issue of concern was more cultural and had two components to it. One component was, "How do they affect under-represented groups in engineering, i.e., women and members of minority groups?" An allegation is frequently made that some foreign-born and foreign engineers come from cultures where women are second-class citizens and that cultural attribute comes through in the way they deal with women in this country. What happens is that women become unenthusiastic about considering careers in engineering as a result of their contact with such faculty members or teaching assistants. The allegation is also made with respect to members of the minority groups, particularly blacks.

With respect to the cultural attitude towards women and minorities, there was much debate within the Committee about this issue and its relevance. There are no hard data to document, that either refute or confirm this allegation. As a result, it was very difficult for the Committee to evaluate the implications of this allegation. Thus, it concluded, "We don't know, but there is enough concern about it, that it must be further evaluated as an issue."

The third area was the effect of foreign engineers in the academic work force. Their effect on engineering education was much more subtle and, I think, much more relevant to your concerns. That was the issue - how these foreign faculty affect the character of engineering education. My simple way of trying to break this issue out is to think about two types of engineering education. One which is frequently called engineering science, where the emphasis is on the analytic, modeling and theoretical aspects of engineering. The other dimension of engineering education is called "hands-on" engineering--the design, the practical end of what engineers do. The concern that the Committee addressed was that foreign engineers from some cultures come with an orientation towards engineering science; towards the theory, towards the analytic, and look down upon the practical, the "hands-on". If that attitude is conveyed, particularly to undergraduate students, this may have very serious implications, given the kind of engineering that we need today to maintain our competitive edge and to stay even with the rest of the world.

The Committee deliberated at great length. Examples were drawn of people who had that attitude and counter examples were drawn of people who didn't. Some members of the Committee noted the fact that these foreign engineering faculties with this analytic bent are being hired by faculty which is predominantly non-foreign and that may say something about the philosophy and direction of engineering education in this country. That may be a more fundamental question that needs to be raised.

Again very little hard, systematic evidence was available that could support or refute that allegation. But the allegation is being felt strongly by many in the engineering community. Therefore, it was felt that it couldn't be ignored. So the Committee put it on the table as an unresolved issue.

The final issue can be paraphrased as, "Is it wise policy to subsidize the training of foreign students?" This issue comes up again and again in state legislatures and the Halls of Congress. It is a very important issue in terms of education policy and how it interacts with the question of foreign engineering in our country. On this issue the Committee was much clearer about how it felt. They concluded that it is a wise policy. The reason it's wise policy is a very large fraction, about 60% of those who are here on temporary visas and 90% who are here on permanent visas, stay in this country. It varies by field and, if I recall correctly, civil engineering is one of the fields in which a relatively large fraction go back compared with other fields. Nevertheless, a large fraction do stay here and contribute to our society. Moreover, their quality is high. Finally, many of them come as students and

eventually parlay their student status into naturalized citizenship status. They come with education up through the undergraduate level already in hand. So you could argue that we are being subsidized by the home country of these students for their pre-graduate school educations. So for all those reasons, the Committee thought that allowing the foreign students to study in our graduate schools was wise policy.

Several ancillary issues were also raised by the Committee. One of the questions was, "Do these foreign engineers displace Americans either in the work force or in the graduate schools?" The answer was no. If these engineers were not here, certain jobs would not get done and some engineering departments would have difficulties in terms of filling their available slots.

Another ancillary issue was, "Do these foreign engineers lower the wage rates of American engineers?" The answer to this question was also no. If you look at data, and we did have some analysis that we could draw on here, that compared salaries of American and foreign-born engineers, controlling for a wide variety of characteristics (i.e., their age, their field, whether they're in the academic sector or the industrial sector, education levels, etc.), there was no difference in the earning rates of foreign engineers and American engineers. On the other hand, the fact that these engineers add to the supply of engineering talent available to our work force, tends to lower the average wage of all engineers. Just simple economics of supply and demand analysis tells you that a larger supply means less upward change in wage rates.

Those were the major issues. Now let me talk to the recommendations that came out of the report.

I think the most important recommendation was not explicitly emphasized in the report: "Don't do anything to make it more difficult for these foreign engineers to come into this country." I personally believe there is a lot of xenophobia in this country about the presence of foreigners in our work force and in our society. The Committee report clearly shows that, in engineering, these workers are important and essential. Thus, any measures that restrict that flow and make that flow more difficult, making it more difficult for firms to recruit and hire these foreign-born engineers, are not wise policy.

The second recommendation addresses the lack of American students. That recommendation is to make it more attractive for American students to pursue a graduate education in engineering. That means increasing the number of fellowships that are available for this kind of education and increasing the stipend levels as well.

We all know that the average beginning engineer coming out of the undergraduate programs in this country can now earn about \$30,000 a year. Moreover it takes six years to get an engineering Ph.d. Multiplying six years times \$30,000 (if you don't get any stipend) the prospective students gives up roughly \$180,000 for a graduate engineering education. Financially speaking, a substantial cost must be overcome to make graduate education in engineering attractive as a package. Thus financial support clearly has to be considered, and it has to be more than the average amount of financial support provided to other disciplines.

In fields such as chemistry, physics, mathematics, for example, the starting salaries for B.A.s is nowhere near the \$30,000 figure I just cited. This may be the reason why engineering has such a large fraction of foreign students and such a small fraction of American students. The returns to an undergraduate education are so high that it doesn't pay to go on.

A third recommendation was that language proficiency should be monitored. That responsibility lies in the hands of the university administrators on the campuses. Before a foreign-born teaching assistant or an assistant professor should be allowed in the classroom, it should be very clear that he or she is able to communicate proficiently. If not, the institutions have the responsibility and obligation to take remedial measures to either give them the language skills or keep them out of the classrooms.

The fourth recommendation is that argument: pre-college math and science education has to be dramatically improved in this country. That, I think, is a commonly accepted conclusion. It's particularly important to say that in engineering, however, because without the requisite math and science competence coming into the colleges, the student considering an engineering career is at a very extreme disadvantage and may not succeed. In effect the pool of possible engineering talent is constricted if you don't allow students the right kind of education in science and math before they enter college.

Another recommendation was made to develop a firmer factual base on which the issue of the quality of engineering education, and what might happen to it as a result of foreign presence, could be judged. We need more hard data. We also need more hard data on whether or not there is a difference between foreign engineering faculty and teaching assistants and native born faculty with respect to their performance in the classroom, their ability to communicate with students, their attitudes, and whether the foreigners are more likely to turn off women and minorities.

Finally, there is a need to examine more extensively the characteristics of engineering education and how it might be influenced by the increasingly important role that's played by foreign faculty. As I mentioned earlier, the issue of the character of that education raises fundamental questions and goes beyond just the foreign born questions.

Foreign Engineers--Implications for Transportation Engineering:
An Academic Perspective
by
Lester A. Hoel
University of Virginia

Judging from the composition of the panel, each of us is to respond to this issue from his own perspective: that of the university, the consultant and the state DOT. In preparing my comments for this session, I identified a few questions and then tried to answer them.

My first question as an educator is, "Why are we seeing so many foreign-born students in our engineering programs?" Note, this phenomena does not exist to the same extent in other professional fields.

Part of the answer is in the nature of engineering as a profession. In the United States this field has historically attracted the sons and daughters of blue collar workers, because it was perceived as an entry into the world of leadership and decision making, where scientific and mathematical skills coupled with understanding of technology, are the prime requisites for respect, financial reward and advancement. Engineering has traditionally been a "boot strap" route from the factory to the board room. It provided a route for an individual with little in the way of cultural and social advantages to practice professionally as an individual, or head a government bureau or a division in a private corporation. Other professions like law, medicine and business typically require more financial support and a greater number of years of education to be qualified, and often required a network of connections for admittance to the better schools and development of a successful practice. The culturally or economically disadvantaged had a much greater probability of success in engineering than in these other professional fields.

Today the disadvantaged blue collar worker's son or daughter (many from emigrant backgrounds) no longer exists in large numbers. This group is being replaced by bright foreign students who see the opportunity for "making it" in this country by pursuing an engineering career. The opportunity is further enhanced because most U.S. born undergraduates are electing to join the work force upon graduation rather than pursuing advanced degrees. Thus, places in

our professional transportation programs have become available that might not otherwise be there if a larger number of U.S. students pursued advanced studies. The foreign born continue to study because they know that in engineering, "knowledge is power," and if they out perform others in technical areas, there are no other mitigating qualifications that will limit them from being competitive.

While our U.S. students go elsewhere for higher salaries or decide not to pursue advanced studies because salary incentives are lacking, the foreign student continues, knowing that by so doing, job opportunities are assured and salaries will be more than sufficient, particularly in comparison with their home country.

The next question is, "What is the implication for our engineering programs?"

There are two major problems that exist when attempting to educate foreign-born engineering students. The first is deficiencies in understanding, expression, and communications, and the second relates to assimilation into a different cultural environment.

Because foreign-born students are usually highly proficient in math and science, these skills tend to be emphasized in classes and curriculum development. Less attention and expectation is placed on writing, oral and interpretive skills. The engineer that we produce is probably good at traffic flow theory, but does not understand the basis of travel demand. He is probably capable in engineering economy, but does not understand the political and budget process behind transportation decision making. When he leaves the "halls of ivy," he will require considerable additional training and practice before becoming a truly well rounded transportation engineer. Some of you may recall the TRB Conference on Transportation Education and Training, sponsored by this committee, and the conclusion of the conference that transportation engineers should have a broad based education, which in addition to basic computer and analytical skills, also included training in communications and management that provided perspective, a global outlook and a feel for entrepreneurship. Quite frankly, this is a tall order under any circumstance but difficult, if not impossible, when dealing with students who have not articulated in the secondary schools and colleges in this country.

A natural response might be, well why not limit their admittance only to bright students with the requisite linguistic and cultural backgrounds? The practical answer is, the professors who need these students to do their research would (and do) object, because the skills and willingness to work long hours under direction, is exactly what is required to do high-quality research. In Virginia for example, admittance of international students has been limited to 15-20% of the graduate students in engineering, and TOEFL language score minimums have been raised from 550-600 actions which have not met with enthusiastic support from the faculty.

A second issue is the use of foreign graduate students as teaching assistants. This TA route has been a traditional way of providing financial support to graduate students, and again we have often let expedience guide our decisions, to the detriment of our educational product. Teaching assistantships not only help to attract students, but they provide assistance to relieve the faculty from doing what the outside world thinks it should do (i.e., teach), so it can devote its energies to what the administration really wants it to do, namely attract research funds and do scholarly work. The reward system in any major university is biased toward research (although some schools do more than just lip service for teaching) and any professor who wants to get ahead will look at the short run benefits (i.e., his tenure and promotion) of employing a foreign graduate student over any long term national impact that may result from this action. In this arena, it is the administration that must establish guidelines to assure quality education and to certify that the graduate student is in fact capable of communicating with those undergraduates under his control.

To do less is to short change the students who have enrolled in engineering and to enhance the possibility that they may seek careers elsewhere.

A third question is, "Why are there so many foreign-born professors at our universities?"

The answer is twofold. First, many foreign engineers view university teaching as a high-status profession and second, the criteria for selection and promotion of university faculty are consistent with the achievements of this group. While the preponderance of young native-born engineers does not aspire to teach, this is not the case for the foreign engineer. Those of us who have recruited engineering faculty know this to be the case, as we are accustomed to receiving many more applications for teaching positions from non natives than from our own countrymen.

We also know that when we examine credentials carefully, particularly at the non-entry level, we find that often the top candidates, in terms of research grants awarded, papers written, and external recognition, were born in other countries. Thus it shouldn't be surprising that a large fraction of engineering faculties in transportation and other disciplines, consider English to be a second language. (In my department, for example, of 16 faculty, over 25% were born outside the U.S.) Furthermore, those of us who have been involved in hiring very senior faculty - at a "Chair" level, know that the best and most sought after candidates are often foreign.

Finally, let me address the question, "Is there a problem and if so, what should we do about it?"

First, my bias. Philosophically I support the American system which promises opportunity for anyone in this country who is legally able and willing to work and wishes to advance himself. As the son of an emigrant, I applaud and welcome all those who are here, and wish them success in their endeavors. I believe that our country is stronger and more prosperous because of the infusion of talent, energy, and risk taking by those who come to the U.S. from other lands.

I do believe, however, that we can do more to strengthen our system of professional education in transportation and the production of professionals in transportation.

First, we can raise compensation levels which recognize advanced training. This should result in a larger number of U.S. students in our graduate programs.

Second, we could provide financial support to those citizens who intend to pursue careers in teaching, as well as for highly qualified students who wish to pursue an advanced degree.

Third, we could include requirements that focus on communications, policy and an understanding of the context within which transportation operates.

Fourth, a greater emphasis could be placed on teaching skills in hiring and promotion decisions.

Fifth, we should strive to advance the image of engineering as a profession.

In summary, the presence of foreign engineers in our midst is both an opportunity and a challenge. The climate exists such that today this group is prominent both in engineering practice and education. They bring enormous benefits to the U.S., and we are a stronger nation because they are here. Transition and adjustment are required on both sides, but this has been the American story since its founding. Our ability to resolve differences and problems will assure that the final result is better transportation for our nation.

Consultant's Perspective on the Implications of
Foreign Engineers On Transportation Engineering

By

Walter H. Kraft
Edwards and Kelcey, Inc.

I'm happy to be invited to share my views on a topic I think is very important. It is a topic we need to discuss and know more about to help us meet our future challenges.

What I would like to do is divide my remarks into five areas by asking the following five questions:

- What is a foreign engineer?
- How have consultants used foreign engineers?
- How is the foreign engineer different than the U.S. born engineer?
- What is the anticipated future supply of U.S. born engineers?
- What types of engineers are needed in the future?

To answer the first question, "What is a foreign engineer?", we can look at the following combinations:

- Foreign born person of non-U.S. parents.
- Foreign born person of U.S. parents.
- U.S. born person of foreign parents.
- U.S. born person of U.S. parents, who have lived outside the United States.
- U.S. born person that studied engineering outside the United States.
- Foreign born person that studied engineering outside the United States.
- Foreign born person who studied engineering in the United States.

Perhaps the answer to the question is any person who is not born in the United States and did not study engineering in the United States. But then I also ask myself is it really important to have such a distinction. Aren't we really looking for people with certain abilities that can apply their engineering skills at certain locations? Well, for a moment let us define a foreign engineer as a non U.S. born person that did not study engineering in the United States.

How have consultants used foreign engineers? It's not a new situation for U.S. consultants to use foreign engineers because U.S. consultants have worked outside the United States for many years. When they've gone to other countries, they've worked together with foreign consultants either on a prime or sub-consultant basis. They've also hired local engineers in these countries, which would be foreign engineers by our definition. These have been positive situations and experiences. In this country, we have an affirmative action program that we all try to meet. We hire foreign engineers as well as U.S. engineers to help us meet certain goals. That has also been a positive experience. There have also been some not too positive experiences where foreign engineers are hired to work in the back room at less than prevailing salaries.

The next question is "How is the foreign born engineer different than the U.S. born engineer?" There are six issues we can examine:

- Immigration and work status.
- Communication skills.
- Cultural and religious differences
- Work ethic.
- Engineering expertise.

Let us look at the first issue - immigration and work status. As consultants, we are interested in knowing if a person's status in this country is legal. We don't want to hire somebody that is here illegally. We are interested in knowing if there is a time restriction on the foreign engineer's stay in this country. We are also interested to know if an engineer is allowed to work even if he or she is in the country legally. We don't want to hire and train a person and have that person leave in a short period of time. Any time we hire an engineer, whether U.S. or foreign born, we train them. It takes from six months to a year for a new engineer to be proficient in applying the skills that have been learned.

Most foreign engineers, as well as many U.S. engineers, lack adequate communication skills. One's ability to communicate with a foreign engineer is frequently hindered by the foreign engineer's accent or lack of proficiency with the English language. Recognizing this situation some state registration boards require some foreign engineers to pass an English proficiency exam before they are granted a license.

Cultural and religious differences are experienced in such areas as holidays, working hours and foods. Common cafeterias must recognize the differences in food. Gift giving is another difference. A few years ago, at Christmas time, I was embarrassed because a foreign born engineer gave me a gift which I thought was rather expensive. I knew the person was a new engineer, and was not in a high income bracket. I wish that I had the foresight to inform the person that in our country we do not expect to give or receive gifts. Instead, I talked to him afterwards and said that the gift was appreciated, but we don't give gifts in our country. The discussion was a bit awkward for both of us.

Foreign engineers also need to acquire an understanding of what solution will work and what won't work in our culture. Some solutions work better in one culture than in another.

Foreign engineers have an excellent work ethic. They are loyal and dedicated. In fact, they remind me of the new person on the block that tries to improve, do well, and move ahead. Because they work hard, foreign engineers tend to move ahead quickly. What about a foreign engineer's experience? I think their experience is mixed. Some have experiences similar to that obtained in the United States. Others don't. In some cases, they have come from areas where solutions are more labor intensive than machine intensive. They also come from areas that use different design standards which requires adjustment. But we also have different design standards in this country between states and cities, so I don't really see different standards as a problem. Foreign engineers tend to be more analytically oriented which may be due to their degree of communications skills. Computer language is universal and may be easier to understand than another language.

Well, what about a foreign engineer's expertise? I can only say it's excellent. Engineering principles are the same worldwide. We may apply them differently but the expertise that we have learned is universal. Let's look at some of the projects at the pyramids, or Roman roads, or the Great Wall of China. These were designed and built by foreign engineers, not U.S. engineers. Also let us look at the expertise that's demonstrated by the cars and computers that are imported into this country. I think that engineering expertise is universal and should not be a point of concern.

What is the anticipated future supply of U.S. born and trained engineers? I think it's very bleak. We have a shortage now and the shortage is expected to continue in the future. I would like to relate an experience that I had when I was President of the Institute of Transportation Engineers in 1987. That office gave me the opportunity to visit many local sections and districts in North America. At every meeting I asked this question: "Is there a shortage of engineers in this area?" At all meetings except one, I was told yes. In that one meeting, I asked the wrong question, because at that meeting, there were mostly engineers in government that had restrictions on hiring. If they

could have hired, they would have hired. My informal survey told me that we have a real shortage of engineers in North America. Let us look at the future. We know that the supply of U.S. born students is declining. We also know that many engineers in government will be retiring. Furthermore, in the past ten to twenty years government did not hire as many engineers as they had previous to that time. We have a reduction in supply and an increase in demand. We need to look for alternative sources of supply.

What type of engineers are needed in the future? I don't think it is a question of whether an engineer is foreign born or U.S. born, but a question of abilities. We need engineers with good technical skills, with related experience and with good communication skills. Just as a new U.S. graduate must be shown how to utilize his/her engineering education, foreign engineers must also be shown. The total effort for the U.S. graduates and for the foreign engineers may be the same; however, areas of emphasis for each one may be different.

In conclusion, let me say I don't think it is important whether a person's engineering knowledge has been acquired in the U.S. or in a foreign country. We should continue to use foreign engineers in the United States as we have done in the past and use them for their experience and their expertise, and also to compensate them fairly for their efforts.

There are differences between foreign and U.S. born engineers that can be minimized. This is a task that we can accomplish. Our anticipated supply of new engineers will fall short of our future needs. To achieve our goals we need engineers with good technical skills, related experience and communication skills.

Foreign Engineers--Implications for Transportation Engineering:
Public Sector Perspective
by
George Gray
CALTRANS District 4

I'm going to speak about the problems that we see as a major employer of the graduates of the various universities.

Since January of 1987, CALTRANS, the California State Department of Transportation, has hired about 1,150 entry-level engineers, 690 in 1988. About half of these are foreign trained or foreign born. Such major recruitment is probably having a significant effect on the pool of potential advanced degree students in the universities. This may become a problem that the universities and we, as users, will have to face in the future. Future masters and doctoral degree students may be siphoned off and we, as a possible employer of those students, should be sensitive to that possibility and consider how we can address the problem if it develops.

For the next several years we hope, with financing vagaries and the political process willing, to hire between 300 and 400 entry-level engineers per year. To give an idea of the diversity of this infusion, in our San Francisco District that now has by far the largest proposed construction program in the state, the makeup of the 376 new entry-level engineers whom we have hired in the last two years is about 8% foreign-born Hispanic, (we have another segment of native-born Hispanic), 9% Filipino, 4% black African, 5% Indian subcontinent, 3% Vietnamese, 11% Chinese, 15% Middle Eastern, and 5% other, including three emigres from Russia and three from Japan.

This diversity provides an example of why communication skills in English is important. It is not only communication between the native-born English engineers within our organization, but also it's the Indian speaking to the Vietnamese and the Russian speaking to the Filipino. So it is especially

important that these foreign-born employees have or develop good communications skills in English.

Of these 1,150 entry-level engineers statewide, only 67 or roughly 3% are foreign trained. Most of the foreign born are products of U.S. universities. Although we recruit nationwide, most of our recruits come from west of the Mississippi. Over the past two years, we've taken much of the graduating engineering classes from many of the western universities. In fact, last year it is estimated that we took 25% of the engineering graduates of all of the engineering schools in the United States who were looking for U.S. employment. To give an idea of the impact, from University of California, Berkeley, we had 69 (11 of those being foreign born), from University of California, Davis, 79. We recruited 20 from three universities in Arizona; from three universities in Utah, 23; from nine institutions in Texas, 59; from Missouri, 20; and from Washington, 11. That gives you an idea of the geographic areas encompassed. From some of the universities in California, we took virtually the entire graduating class.

To give a perspective of the talents these foreign-born engineers bring with them, we have, for example:

Rhodes Scholar from Ecuador with a Master's Degree from University of California, Berkeley.

Czech Ph.D. who has written engineering books in German.

Indian with extensive experience in teaching computer-aided drafting and design.

Three Middle Eastern Ph.D.s in Civil Engineering and one Ph.D. in Environmental Engineering.

Chinese Ph.D. pavement specialist.

Rumanian Ph.D. metallurgist and a Rumanian with extensive rail management experience.

Twenty-five Middle Eastern engineers with Master's Degrees.

Obviously a group with many and diverse talents. In fact, as a group we have no qualms regarding their technical competence and abilities. Further, we have found that many of the foreign-born engineers have positive job attitudes, possibly because they have been identified as role models in their countries of origin and in their own societies and have need to prove themselves in a new environment.

A major factor in the future importance of foreign engineers and the staffing of the state D.O.T.'s is the transitional condition of the average organization. As a group, the state D.O.T.'s are going through a period of massive changes in:

1. Engineering staff with, in our district of the State of California, 30 of the 1985 work force of engineers being replaced due to retirement by 1990.
2. Role, where maintenance and reconditioning of the aging existing facilities is becoming more important than providing new facilities.
3. Management, with, again in our district, 50% of the 1985 managerial leadership to be retired by 1990. This really

means that, considering the promotion of the present younger middle-management engineers, virtually all of the present management positions within the organization will be staffed by recently appointed people by the early 1990's.

In 1987, an in-house report identified that there are five primary obstacles to a graceful transition and renewal of staff. The first of these is the sheer number of engineering professionals who will retire over the next decade (about 200 statewide per year) and the declining enrollment in the civil engineering programs.

The second, is the difficulty in sustaining a systematic and orderly recruitment program in the face of on-again off-again budgeting. As you are aware, in the United States, the political process is such that as you come closer to the time when those in power run for re-election, the work forces of various governmental entities tend to be frozen or reduced if it is at all feasible. However, when new candidates come in, you may have a little window of opportunity to add to the staff, if everything goes well.

The third obstacle is difficulty in recruiting and retaining top-flight professionals given the perception that challenging work is in short supply. This is related to shifting from building new facilities to the reconditioning of old. Many of the younger people want to build something from the unadulterated ground up rather than take something that is already there and convert it for a present-day use.

The fourth obstacle is the thin ranks of mid-career professionals from which to promote managerial leadership of the next generation, and the fifth obstacle is, the profound social and cultural differences between the engineers of the older and younger generations. The author of this report was not thinking of foreign engineers vis a vis native engineers as much as he was thinking of the social and cultural differences between the generations. Those of my generation tended to be, as Les Hoel said, up from the blue-collar ranks. For instance, my parents were blue collar from Nebraska and the next generation back from Czechoslovakia and New England. These generation differences are compounded when considering the social and cultural differences that the foreign engineers inject into this milieu. It is a significant problem.

I worked for two years in Vietnam for a consulting engineering firm and recently for four years in Saudi Arabia. These experiences have given me some insights into the problems that can arise from cultural differences. In some cultures, the engineer is a technical practitioner and not necessarily involved in determining alternatives and impact, as is expected of the U.S. engineer. On the other hand, in Vietnam, most engineers wouldn't think of going out and looking through a transit, as we U.S. trained engineers were expected to do in our early years. In Vietnam, the engineer was supposed to develop the plans and see that the work was done but not do any hands-on work. An engineer was expected to be a technical practitioner but without hands-on involvement.

Also, in some cultures, social training inhibits consensus building where elders are involved. That was certainly true in Vietnam and to an even larger extent in Saudi Arabia.

Another difference is the depth of family responsibilities. In Saudi Arabia, we had examples of senior Saudi engineers that were very capable, but whose ability to be on the job was hindered because of family responsibilities. In one case, the engineer was the oldest son. When his father passed away, he took over as head of a very large extended family. These family responsibilities made it very difficult for him to carry out his engineering responsibilities.

For some cultures acceptance of members of the opposite sex (or minorities to that culture) in an equal working relationship is difficult. We have, so far, only anecdotal instances of these problems as a factor in our organization.

But I'm afraid the underlying social problems may still be there and we should be sensitive to this and work to assure that they are recognized and minimized.

We also, as expected, have identified communication problems. Although almost all of the foreign-born engineers, including those foreign trained, are competent in technical English, we are finding some are not linguistically able to work with citizen and similar groups. Working closely with local citizen groups is a growing and important part of our process. In addition, writing skills are often in need of improvement, a condition that too often also applies to native-born Americans. I urge the universities, and I'm sure that I don't have to worry about urging the two universities represented here, to address the communication problems, i.e. English writing and linguistic skills.

At present, Caltrans is providing some English-as-a-second-language courses to help remedy the communication problems. We realize the needs in this area will probably call for further remedies. I wrote a note to myself that we should broaden our Toastmasters Club involvement in the District and maybe have a special effort to get our foreign engineers involved. As I mentioned, 60% of our entry-level engineers are now foreign born. We've been especially sensitive to this for years in the San Francisco region. In the past, I could walk down the halls in the design area and hear Chinese now and then, but now I hear a polyglot of languages and we have to be alert that we aren't developing cells of engineers with similar native backgrounds; such inbreeding could hinder their full development. For instance, with the Middle Easterners we have to be sensitive to which ones are Sunni and which ones are Shiites to be able to be sure that we are not developing some future problems.

The second area that will require further analysis on our part and may call for special in-house training, includes adding cultural differences topics to our basic supervision courses.

Also, as a major user of graduates, we need to reconsider our, CALTRANS, present lack of full support of our employees who desire to further their university education and also we need to improve our support of the university engineering programs.

We also should encourage our existing staff engineers to become mentors for potential engineering students before they make their career choices in the universities. I know in my case, when I was a young Army recruit, 17 years old and away from home, it happened that friends of my family knew somebody in the city near my base. I was invited to Thanksgiving dinner and the friend happened to be a senior engineer in what was then the Bureau of Public Roads, now known as the FHWA. That contact continued and it affected my career. We find our staff are not doing enough to avail themselves of the opportunities to help increase the number of students in engineering. For instance, involvement in career days that are given in the various high schools. We hope to work more to encourage involvement in that direction.

Before I close, I would like to digress from my main theme to comment on the importance of engineering in the overall scheme of international relations. In Saudi Arabia, for instance, Canadian Bell is very respected because it set up the modern telephone system. Also much of the Saudi's high regard of U.S. technology is due to American engineers, notably those associated with Aramco, who provided the first hospitals, built the first schools, established the first electric light plant and built the first roads in the kingdom. The American engineer has, over the years played an important role in developing countries. It is fitting that many foreign students, impressed by this American role, have found it logical to seek their engineering education in this country. So, not only U.S. trained native students returning to the mother country give a good connection between the countries but the engineering works that we have been able to provide within their country have certainly gained us friends.

In closing, I would like to quote from the NAE report. "Very significant, positive aspects arise from the presence of foreign-born engineers in our society. It must be recognized that with these foreign engineers, the United

States is attracting an unusually gifted group of individuals with high intellectual competence and diligence. The diversity of intellectual background and experience that other foreign-born engineers have brought in the past greatly contributed to the U.S. engineering competence. There are no reasons to believe that the new immigrants will not contribute similarly."

Thank you.

Foreign Engineers--Implications for Transportation Engineering:
Transportation Industry Perspective

by

Mike Rougas

Association of American Railroads

First, I would like to make a comment of personal nature. I was born in Pennsylvania. When I was 2-1/2 years old, my parents returned to their native Greece. I was brought up in Greece just like any other Greek child. I attended elementary school and high school there and I returned to this country when I was 19. I was too young to remember leaving this country and I learned no English until after I returned. In fact, I returned reluctantly. I thought that perhaps my case would be missed by the statistical categories which were mentioned earlier. The presentation was so thorough though, that even my special case is included in one of the several categories mentioned. I am sure this is not the reason I was invited by Dr. Pignataro to speak to you, because he was not aware of my background. The reason why I brought it up at all was to make you aware that I have seen both sides of the fence so that you can phrase your questions any way you like.

Second, I must confess that I do not feel comfortable representing the transportation industry before you today. Although I have been a railroad person all my life, railroads are only part of the huge transportation system we have in this country. I do feel quite comfortable talking about railroading to you and I hope that what I tell you is somewhat parallel to the experience of the transportation industry at large.

After a 36 year involvement in it, I would say that railroading may be defined as a huge engineering undertaking. Although it requires the services of other professions, its demand for engineered solutions to the available alternatives is insatiable. For this reason, the industry generally needs top engineering talent. This may not be obvious to the general public, but it is true. The demand for engineers fluctuates somewhat. Since the deregulation act of 1980, the railroads have become a lot more competitive and more efficient, and in the process, they have reorganized. As a result of this restructuring, the management staff has shrunk and the engineering positions are not as plentiful as they used to be. Some railroads, though, are hiring a few engineering graduates. I believe the long term trend will improve.

I have met and worked in our industry with foreign trained engineers, foreign born engineers trained in this country, and some with training here and abroad. My observation has been that, in general, they have performed very well.

In the railroad industry, the demand for engineering talent falls in three categories. One is research. Major railroad companies have research departments where they employ engineers. Most of the research for the industry, however, is done by the Association of American Railroads. It is in the railroad research field that I have met many foreign engineers and, in my opinion, they have performed very well.

The second type of engineering positions for which normally there is a demand is for filling vacancies in the engineering departments of individual railroad companies. These departments require civil, mechanical, electrical,

or industrial engineering talent. The occupants of these positions generally are of the office engineer types-- designers and analysts. I have met several foreign engineers in positions of this type and I am happy to report to you that, here too, they have done well.

The third type of engineering positions for which there is need is in field supervision where engineering is used as a background. These positions require a strong leadership quality to deal with a highly unionized and structured labor force. Communication skills are of paramount importance in these positions. Although I have encountered only one foreign born and foreign trained engineer in field supervision, I feel certain that the railroad industry would be happy to fill their vacancies with anyone who can do the job, indigenous or foreign born.

As for the NAE report, I enjoyed reading it. It is an excellent report. It highlights some social behavior characteristic of foreign born engineers that are different. Without question this social difference creates problems that are evident in the real world. On the other hand, there is hardly a group or an individual that does not present a problem or two. The problems stemming from the social differences described in the report may not be perceived to be as intense when viewed comparatively.

I would like to finish my remarks by saying that the railroad industry welcomes those who possess the needed engineering talent when it is mutually advantageous for employer and employee alike.

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