Gender and Racial Diversity in the Structural Engineering Profession

E. N. Leong[1], A.B. Liel[1], J. Mitrani-Reiser[2], E. Guglielmo[3], D. Friis[4], D. Lumbard[5], R. Oliveira[6], R. Pekelnicky[7]

[1] Dept. of Civil, Env. & Arch. Eng., Univ. of Colorado Boulder, CO 80309 Email: abbie.liel@colorado.edu; eva.leong@colorado.edu
[2] Dept. of Civil Eng., Johns Hopkins Univ., Baltimore, MD 21218 Email: jmitrani@jhu.edu
[3] Martin/Martin, Inc., Lakewood, CO 80215 Email: eguglielmo@martinmartin.com
[4] CDM Smith, Maitland, FL 32751 Email: FriisDL@cdmsmith.com
[5] Degenkolb Engineers, Portland, OR 97205 Email: DLumbard@degenkolb.com
[6] Thornton Tomasetti, Chicago, IL Email: RGomesdeoliveira@ThorntonTomasetti.com
[7] Degenkolb Engineers, San Francisco, CA 94104 Email: RPekelnicky@degenkolb.com

ABSTRACT

This paper summarizes data that examines the gender and racial diversity in the structural engineering profession. The first section describes the representation of women and racial/ethnic minorities among university faculty and students in the area of structural/civil engineering, among licensed professional engineers, members of structural engineering related professional organizations and companies employing structural engineers. The second section describes results of a survey filled out by 741 current and former structural engineers. Survey responses shed light on differences in career satisfaction, compensation and other experiences between engineers of different genders or races. The paper was conceived by the ASCE/SEI Young Professionals Committee; a complete report will be available from SEI in 2013.

INTRODUCTION

Like many other science and technology related fields, the structural engineering profession remains fairly homogenous in terms of gender (mostly men) and race/ethnicity (mostly white). Although it is well known that women and racial minorities are under-represented in structural engineering, there is a scarcity of information about the demographics of our profession and the factors contributing to these patterns. This study examines the current role of women and racial minorities in the structural engineering profession and investigates what affects these engineers' experiences in the profession.

The first section of the paper reports on data collected to attempt to quantify the representation of women and minorities among 1) undergraduate students, graduate students, and faculty in civil and structural engineering at major universities, 2) professionals registered with state engineering licensing boards, 3) members of regional associations of structural engineers and other professional organizations, and 4) firms employing structural engineers. The goal is to collect data that is representative of the current statistics of gender and racial diversity in the structural engineering industry.

The second part of the study presents preliminary findings from a survey of current and past structural engineering professionals. Analysis of the 741 responses aims to examine and understand the factors affecting the career choices of gender and racial

minorities and the challenges they face in professional development in our profession. Survey questions focused on factors affecting why people choose structural engineering, career satisfaction, compensation, responsibilities and work environment.

CURRENT DEMOGRAPHIC STATISTICS OF STRUCTURAL ENGINEERS

This part of the study reports statistics that attempt to quantify the diversity of the structural engineering profession, in terms of gender and race/ethnic background, as it is today. Race/ethnic data focuses on three groups that have traditionally been underrepresented in technical fields: African Americans, Native Americans and Hispanics; these groups are referred to as "underrepresented minorities" (UM). Individuals who are not white or members of the underrepresented groups, mostly Asian and Indian Americans, are termed "other minority groups".

University Faculty and Students. The study examines the demographics of faculty and students at the top civil engineering university programs in the U.S. Data quantifying the representation of women and underrepresented minorities among university faculty, graduate, and undergraduate students were collected from civil engineering departments, since most structural engineers have civil engineering degrees. Where possible, specific information about structural engineering faculty and students was recorded separately.

The data were collected for the top engineering programs ranked by *US News & World Report* (2012) through two methods: by emailing faculty and staff in the civil engineering departments at the ranked universities, and by searching the American Society for Engineering Education database (ASEE, 2012). Since the ASEE data are aggregated by department, it is not possible to separately distinguish data for faculty and students in structural engineering. In total, we collected results for 41 out of 50 top civil engineering programs in the country. Data for each university includes the total number of civil engineering students and faculty, and the number of each gender or racial group.

Table 1 shows that there are fewer women than men among all cohorts (undergraduate students, graduate students and faculty) and even fewer underrepresented minorities. The percentage of African Americans in every cohort is less than 3%; the percentage of Native Americans is close to zero. However, there is significant variation in the gender and racial diversity among the universities on which the data is based. For example, one university has an undergraduate civil engineering population that is 59% women; another's undergraduate population is 15% Hispanic. Table 1 also shows that the civil engineering data typically report slightly higher percentages of women and minorities than the structural subdiscipline. Moreover, undergraduate students typically consist of higher percentage of women and minorities compared to the graduate students, which are in turn typically higher than the percentage of these groups among faculty. The differences may represent differential patterns of attrition from the field among students of different races or genders or, possibly, a demographic shift in the profession.

Licensed Professional Engineers. Professional licensure is an important step in the career of a structural engineer. Demographic data are collected here for Engineers-in-Training (EITs), professional engineers (PEs), and structural engineers (SEs). The years of experience required before being eligible to become a PE varies by state (NCEES, 2012). The SE is a specialized license beyond the PE, applicable in some states.

Data were gathered by contacting all 50 state licensing boards. States do not

maintain statistics about the demographics of their licensees. However, email responses and state board websites were used to compile lists of names of licensed PEs (in 17 states), SEs (7 states), and EITs (6 states). The data is further complicated because some states group all types of engineers for PE licenses, while some states separate out civil engineering (CE) licenses; although many PEs are civil engineers, this is a simplification. The lists of names were used to estimate the percentage of women among actively licensed PEs, SEs and EITs in each state, using a random sample of 550 names from each list, and common sense to identify the gender of the licensee based on first name. Approximately 10% of names were classified as unknown gender. The lists provide no reliable information about licensees' race.

Table 1. Demographics of university students and faculty in civil and structural engineering.

	FACULTY		**UNDERGRADUATE STUDENTS**		**GRADUATE STUDENTS**	
	Civil	**Structural**	**Civil**	**Structural**	**Civil**	**Structural**
# of Universities Providing Data [Total # of Students or Faculty in each Group]						
	39 [1027]	14 [134]	37 [12805]	4 [973]	38 [6294]	10 [660]
Gender						
% Women	17.7	18.7	26.1	24.3	30.5	20.5
% Men	82.3	81.3	73.9	75.7	69.5	79.5
Race/Ethnic Background						
% African American	1.3	1.5	2.7	1.8	1.8	1.2
% Hispanic	6.3	2.2	9.9	14.9	4.5	2.9
% Native American	0.0	0.0	0.7	0.7	0.2	0.2
% Underrepre-sented Minorities	7.6	3.7	12.6	17.5	6.5	4.2
% White & Other Minorities	92.4	96.3	86.7	82.5	93.5	95.8

Figure 1 reports the gender breakdown of licensed EITs, PEs and SEs. Women are estimated to make up 17.3% of EITs, 7.5% of PE licensees and 2.8% of SE licensees. The decrease in representation of women from EITs to PEs to SEs is consistent with the university data, and may indicate the larger number of women among younger engineers or the loss of women before reaching these licensure milestones.

Structural Engineering Professional Organizations and Associations. The study also collected demographic data from the membership of a number of structural engineering related professional organizations: the American Society of Civil Engineers (ASCE), ASCE's Structural Engineering Institute (SEI), regional chapters of the Structural Engineers Associations (SEA), and the Earthquake Engineering Research Institute (EERI). None of the professional organizations and associations track racial diversity of membership. The gender of ASCE and ASCE/SEI members were obtained directly from ASCE. Data from regional SEAS were gathered from emails to the presidents of the 45 state SEAs, which resulted in 17 responses with gender data. EERI provided the research team with the names of all current members, including students.

Table 2 summarizes the percentage of women among these organizations' members. At 6.7%, the Structural Engineering Institute has the lowest percentage of women of any of the ASCE Institutes; the Architectural Engineering Institute (AEI) and the Environment and Water Institute (EWRI) have significantly higher percentages of women, with 15.8% and 18.4%, respectively. The study also examined the leadership role of women in SEI by looking at the percentage of national and regional committee chairs that are women. Of the national technical committees, 8.9% are chaired by women. It is (coincidentally) also the case that 8.9% of the regional committee chairs are women. The SEA results were computed by taking the number of women members divided by the total number of reported members of the 17 regional SEAs, yielding a national percentage of 9% women. The largest and smallest percentages of women among the SEAs were 11.7% (Washington) and 5.3% (southern Nevada), respectively.

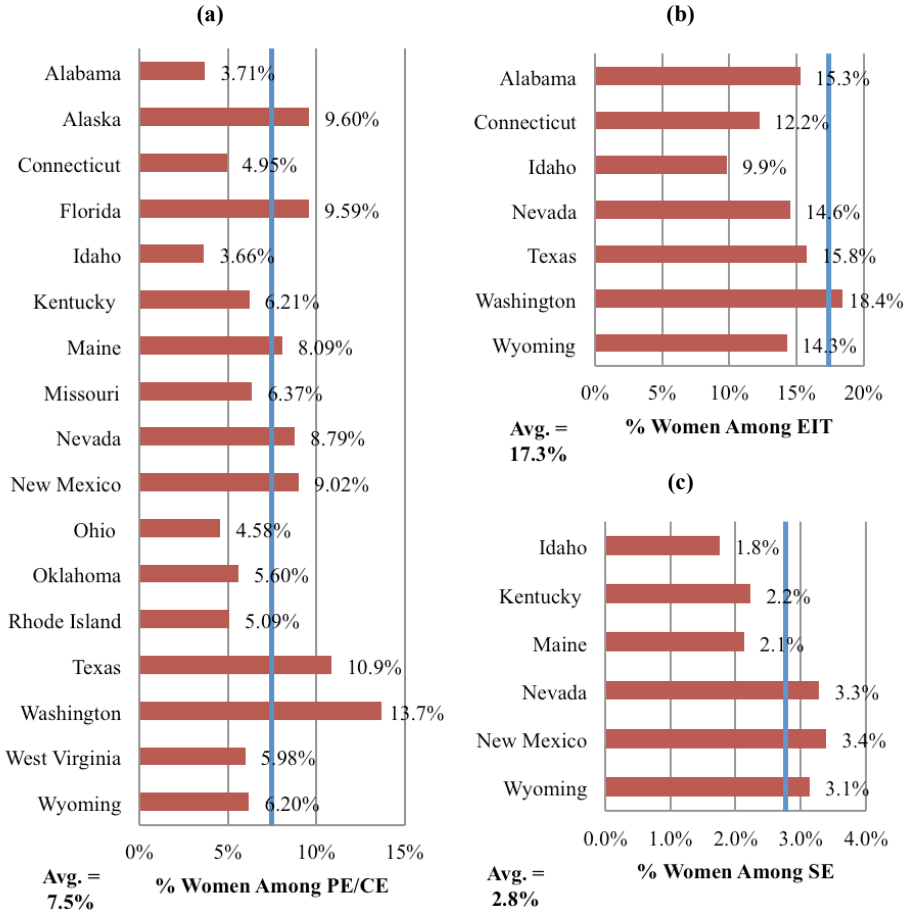

Figure 1. Percentage of women among (a) PEs, (b) EITs and (c) SEs.

Firms Employing Structural Engineers. Gender and racial data were collected from 41 structural or civil engineering companies in the U.S. These companies were identified

through personal contacts, published rankings of top structural engineering companies and other websites. The firms include large firms (with 500+ employees), as well as small local firms. In some cases, structural engineers working at the companies provided our team with the data; in other cases, the information was obtained from human resources personnel. The individuals represented by this data are structural engineers at all levels in the company, and including those with structural engineering training, but in management positions. Other staff and drafters are excluded. The data may be limited by the selection of firms included, which relied on our professional contacts.

Table 2. Gender of members of structural engineering professional organizations.

	Description of Members	% Women	% Men	Unknown
ASCE	Civil and structural engineers	11.8	86.4	1.8%
ASCE/SEI	Structural engineers	6.7	91.3	2.0%
SEI Committee Chairs	Structural engineers	8.9	91.1	n/a
Regional SEAs	Structural engineers	9.1	90.9	n/a
EERI	Civil/structural engineers & others in earthquake eng.	7.4	92.6	n/a

The demographic data obtained from structural engineering firms are illustrated in Figure 2. The numbers reported are the percentage of women, Hispanics, African Americans, or Native American among all participating companies (*i.e.* # of women at all companies/# of engineers at all companies). The percentage of women reported by structural engineering firms (17.1%) is somewhat higher than the percentages associated with professional memberships or PE licenses, which were below 10%. African Americans are much less represented than Hispanics, and the total percentage of underrepresented minorities is about 7%. The data collected also included demographic information about structural engineers according to their position in the company. Engineers were categorized by the positions listed in Table 3; Figure 3 examines the percentage of women and of each race/ethnic group among engineers holding different positions. A smaller percentage of women and underrepresented minorities hold the more senior positions (associate and higher) as compared to men and white engineers.

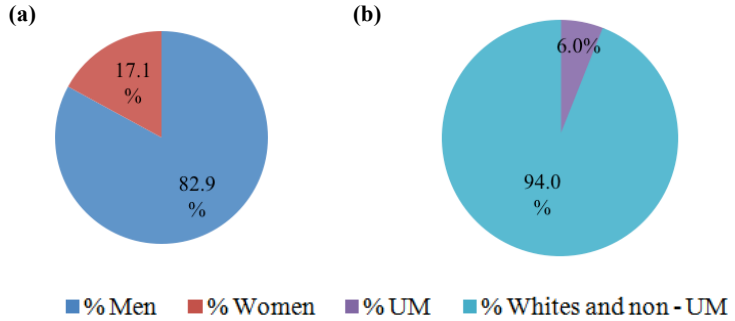

Figure 2. Demographics of structural engineers working at U.S. firms by (a) gender and (b) racial/ethnic background.

Table 3. Titles/positions of structural engineers working at U.S. firms.

Title or Position	% of Structural Engineers
President/ Partner/ Owner	2.5
Vice President	2.9
Principal	14.9
Associate	14.5
Senior Engineer	17.3
Project Engineer	10.3
Engineer	17.8
Structural Designer	3.7
Engineer-in-Training	11.7
Other Positions*	4.3
Total:	100

* The request for data asked for the number of people who have a civil/architectural engineering degree; therefore, we assume the people identified as others are structural engineers

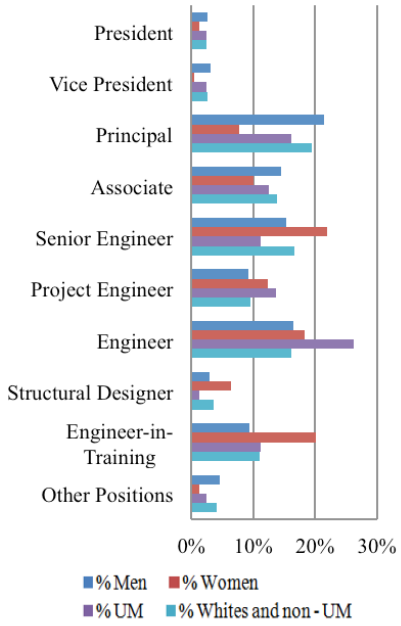

Figure 3. Demographics of structural engineers at U.S. firms, by position.

SURVEY OF STRUCTURAL ENGINEERING PROFESSIONALS

Survey Description. This part of the study reports on responses to an online survey distributed to structural engineering professionals. These responses are used to describe the experiences of structural engineers, from their initial decision to pursue a career in structural engineering, to their current roles and responsibilities, compensation, and career satisfaction. The critical question from the perspective of this paper is how much these experiences differ according to an engineer's gender or race/ethnic background.

The survey targeted participants who are either currently working as, or have previously worked as, structural engineers. A link to the web-based survey was disseminated through email and other electronic media to colleagues, collaborators, acquaintances, and classmates of members of the ASCE/SEI Young Professionals committee. These individuals were asked also to forward the link to others. To obtain as broad a distribution as possible, the survey was posted on social media sites *Facebook* and *LinkedIn* and distributed to ASCE/SEI committee chairs, ASCE local chapter chairs, regional SEA presidents, and membership of the SEAs of Colorado (SEAC) and Northern California (SEAONC). The survey was also advertised in the Colorado Section ASCE, EERI and SEI Update newsletters, and the SEAoNY website. Finally, the team emailed the survey to structural engineers at state Departments of Transportation.

Demographics of Survey Respondents. A total of 741 individuals responded to the survey; this paper describes the responses from 728 individuals who reported their gender and race/ethnicity, live in the U.S. and answered all of the required questions. Of these survey participants, 73% are men and 27% are women. The distribution of survey

respondents by age is summarized in Figure 4. The average male and female respondents are 37 and 32 years old, respectively. Survey respondents' race/ethnic backgrounds are summarized in Table 4. Together, Hispanics and African Americans made up 5% of those surveyed; there were no responses from Native Americans. Interestingly, there is greater representation of women, Hispanics and African Americans among those surveyed than observed in the data described in the first part of this paper. Women and minorities may have been more likely to fill out the survey. In addition, women appear to be more represented among younger engineers who constituted the bulk of survey respondents; survey participants under the age of 35 are 66% men and 34% women. Like the entire survey group, those under 35 are 84% white. The rest of this paper describes only the 620 responses received from individuals who are currently structural engineers.

Factors that Led Respondents to Pursue Structural Engineering Careers. Survey participants responded to questions about when and why they chose to pursue structural engineering education and careers. Almost all the respondents reported that they chose structural engineering sometime during their college education. These patterns appear to be very similar regardless of gender, but may indicate that underrepresented minorities decided on a structural engineering career slightly earlier in college than others.

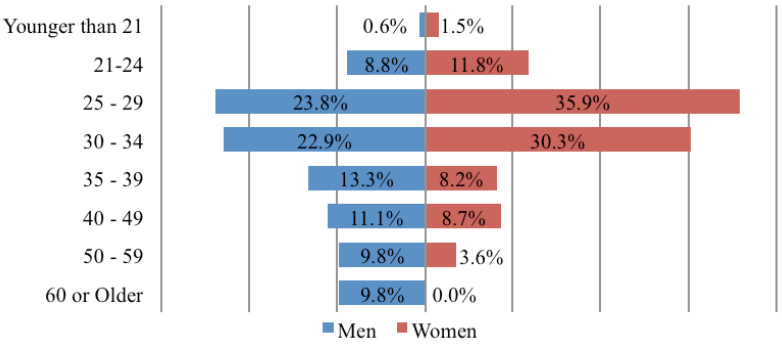

Figure 4. Age distribution of survey respondents.

Table 4. Race/ethnic background of survey respondents.

Race/Ethnic Background	%
White	84%
Asian American or Pacific Islander	8.9%
American Indian or Alaskan Native	0.0%
Hispanic/ Latin American	3.7%
Black/ African American	1.1%
Prefer not to answer /Other	2.4%

Responses about why participants decided to pursue education and careers in structural engineering are summarized in Table 5. Regardless of demographic characteristics, respondents were most likely to choose the same three factors (italicized in table), including interest in math or science and engineering is practical. Men were more likely to report the importance of an interest in science or the practicality of engineering, while women were more likely to report an interest in math. Among the

factors of secondary importance, women were more likely than men to choose reasons associated with family or friends (8.4% vs. 7.2%) and teachers or mentors (7.2% vs. 5.7%). They were also slightly more likely to select the option about making a difference (7.3% vs. 6.0%). Conversely, men were more likely to note the importance of an internship (7.2% vs. 5.7%). Underrepresented minorities were more likely than whites to select teacher/mentor encouragement (7.8% vs. 6.1%), but less likely to select reasons related to family/friends (6.2% vs. 7.3%). Survey participants also said that they chose the structural profession because they like buildings. Others said that they wanted to be an architect, but felt that they are not artistic enough.

Table 5. What factor(s) led you to pursue a career as a structural engineer?

Factor *	% of Men	% of Women	% of Whites	% of Underrepresented Minorities	% of Other Minorities
Family member or close friend was/is an engineer	7.2%	8.4%	7.3%	6.2%	10.7%
Teacher/ mentor encouragement	5.7%	7.2%	6.1%	7.8%	6.1%
Interest in math	*18.7%*	*22.6%*	*19.9%*	*22.5%*	*16.5%*
Interest in science	*18.2%*	*14.8%*	*17.0%*	*20.9%*	*16.9%*
Engineering is practical	*18.5%*	*14.8%*	*17.7%*	*14.0%*	*17.6%*
Job/ internship experiences	7.2%	5.7%	7.2%	6.2%	5.0%
Other past opportunities, activities, summer camps	1.6%	2.4%	1.7%	3.1%	2.7%
Desire to make a difference	6.0%	7.3%	6.1%	4.7%	11.1%
Wanted to get a degree that would provide a solid foundation for another career or field	3.3%	3.5%	3.1%	6.2%	3.4%
Looking for a good compensation and stability in my career	8.1%	10.0%	9.2%	6.2%	5.4%
Others/Not Sure etc.	5.6%	3.2%	4.6%	2.4%	4.6%

*In this question, respondents were asked to identify the three most important factors from a provided list.

Figure 5 reports survey participants' evaluation of their own confidence in their technical skills during their education, showing differences in confidence depending on the respondent's gender. Men were more inclined to say that they were confident throughout their education, while women chose options like somewhat confident, or indicated increasing confidence. The majority of underrepresented and other minorities reported a high level of confidence throughout their education. However, members of these groups were also less likely to say that their confidence had increased during their education, in comparison with white respondents.

Roles and Responsibilities. Survey respondents included engineers who had just started their careers and those who had been structural engineers for more than 30 years. The data show that the average male respondent has worked in the profession slightly longer than the average female respondent (12 vs. 7 years). Although it is difficult to know if the survey sample is representative of the structural engineering profession, these differences

may represent the changing demographics of our profession, with increasingly more women. There are no differences in respondents' years of experience based on race.

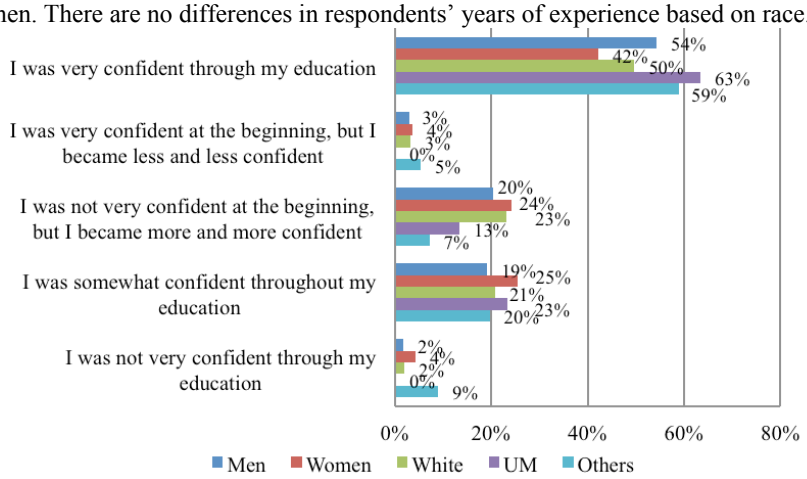

Figure 5. Did you feel confident about your technical abilities during your university education?

The positions held by the survey respondents are shown in Figure 6. In percentage terms, women have greater representation among the more junior positions (Engineer and Project Engineer), whereas men are more represented at the level of Senior Engineer and above. There also tend to be a larger percentage of underrepresented minorities at the more junior levels, particularly Engineer. However, underrepresented minorities were much more likely at the principal and associate level than women. In terms of technical responsibilities, men and women reported having similar roles and responsibilities. However, more men (54%) than women (28%) are responsible for managing at least one person. On the other hand, underrepresented minorities were more likely than whites to report that they are responsible for managing at least one other person (63% compared to 47%), reflecting their presence in management positions.

Compensation. Figure 7a shows the salaries reported by survey participants. On average, the survey respondents who provided their salary earn $85,500 per year. The average annual salary is higher for men ($91,000) than women ($71,000). When separated by respondent's race, the average annual salary is higher for the underrepresented minorities ($89,800), than whites ($86,200) and other minority groups ($78,500). This somewhat surprising observation may be due to the small number of salary data points gathered for underrepresented minorities (21) and the presence of some of these engineers in management positions. In Figure 7b, salary is plotted as function of the respondents' years of experience. (The data points for individuals earning more than $250,000 are not shown for clarity.) The trendlines show that men slightly earn more than women, even when engineers with the same years of experience are compared. Although the data is limited for the underrepresented minorities, it appears that their salaries are on par or higher than white engineers.

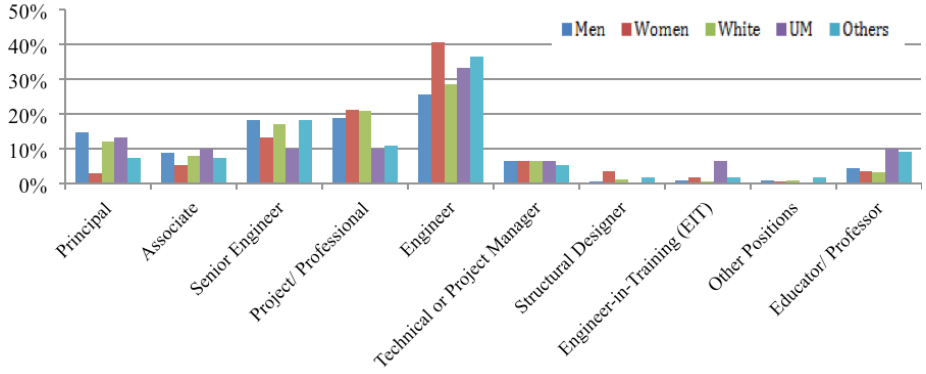

Figure 6. Survey respondents' current position or title.

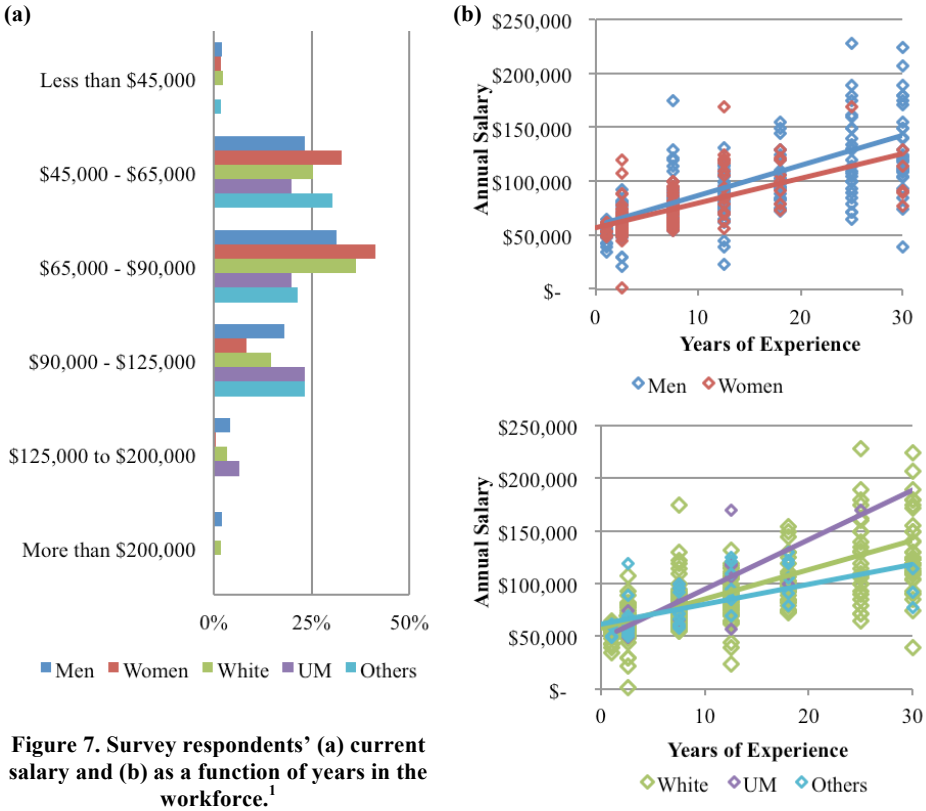

Figure 7. Survey respondents' (a) current salary and (b) as a function of years in the workforce.[1]

[1] The years of experience are lumped based on the survey choices. Those with more than 30 years of experience are plotted at 30.

As another measure of professional satisfaction, the survey asked participants if they had worked for more than one structural engineering company and, if they had, what were the reasons why they left the previous employer. We also asked the participants if they had considered leaving the profession since they had started working as a structural engineer. As shown in Table 6, among structural engineers who have worked for more than one company, women are significantly more likely than men to have thought about leaving the profession. This gender difference is not apparent among those who have worked only at one company. The data also suggest that underrepresented minorities are significantly more likely to consider leaving the profession. The desire for more opportunities for career advancement was frequently cited as a reason for switching companies or considering quitting structural engineering. However, women more frequently selected reasons of better work life balance and better work environment and men more frequently selected reasons about financial compensation. Whites were also more likely than underrepresented minorities to cite financial compensation as a reason to switch companies or consider a different career.

Abbie Liel 6/3/13 9:43 PM
Deleted: Table 6

Table 6. Percentage of respondents who have thought about leaving the structural engineering field.

	Thought about leaving
Worked for more than one company	43% of Men, 64% of Women, 46% of Whites, 65% of Underrepresented Minorities, 55% of Others
Worked for one (current) company only	37% of Men, 38% of Women, 36% of Whites, 60% of Underrepresented Minorities, 40% of Others

Perspectives on Diversity in Structural Engineering. In the final section, the survey asked about respondents' perceptions of equality in the workplace. Responses to the question about discrimination and discomfort in the work environment are reported in Figure 8. Although most of those surveyed said they had not experienced discrimination, women and underrepresented minorities were much more likely to answer "yes" than men or whites. Figure 9 reports that women and underrepresented minorities are much less likely to believe there are equal opportunities for everyone.

CONCLUSIONS

The demographic data obtained from universities, engineering licenses, professional organizations, and structural engineering companies, show that women are most highly represented (making up about 20%) among university students and faculty, and in the data from structural engineering firms. There are much smaller percentages of women (<10%) found by looking at professional society's membership and state licenses. This may be due to differences in seniority among women and men and among those who chose to participate in professional societies. The data are more limited regarding racial/ethnic background, but indicate that approximately 1% of structural engineers are African American, 5-6% are Hispanic, and very few are Native American.

Results of the survey of structural engineering professionals shed light on the different experiences of women and racial minorities in our profession, as compared to whites and men. Survey responses show that gender and racial minorities select structural engineering and consider leaving structural engineering for different reasons than others. The data also suggests that women are less represented in management

positions than among younger engineers, earn less money than their counterparts and are less satisfied with their careers. In contrast, the number of underrepresented minorities is small, but these individuals seem to achieve greater parity in salary and other career experiences than women.

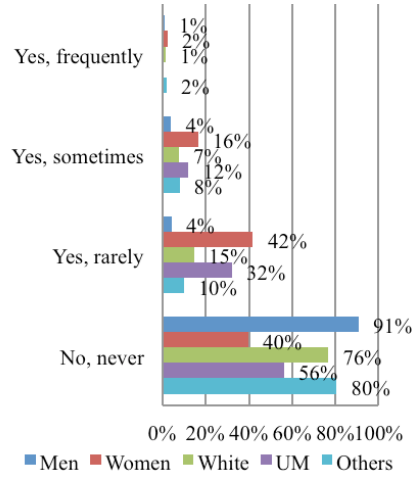

Figure 8. Have you been discriminated against or encountered an uncomfortable work environment as a structural engineer because of your race, gender, or for other reasons?

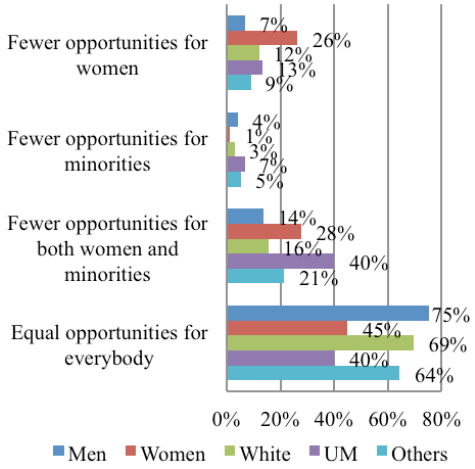

Figure 9. Do you believe some groups of people have fewer opportunities to succeed in structural engineering careers?

ACKNOWLEDGMENTS

This paper reports on an ongoing effort by the ASCE/SEI Young Professional's committee to examine the unique issues faced by women and minorities in the structural engineering profession. The effort is funded by SEI. The authors are grateful to all of the survey respondents and others who provided the data described in this paper.

REFERENCES

American Society for Engineering Education (ASEE). 2012. *College Profiles*. Washington D.C. Retrieved April 2012 from http://profiles.asee.org/

National Council of Examiners for Engineering and Surveying (NCEES). 2012. *Licensing Board*. Seneca, South Carolina. Retrieved February 2012 from http://ncees.org/licensing-boards/.

U.S. News & World Report 2012. *Best Engineering Schools in Civil*. Retrieved January 2012 from http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-engineering-schools/civil-engineering-rankings