America's Research-active, Geotechnical Faculty Members - an Investigation of National Science Foundation Funding Trends

D. F. Laefer[1], S. Akter[2], and C. McHale[3]

ABSTRACT

This paper is an investigation of the National Science Foundation (NSF) funding trends within America's research-active tenured and tenure-track, civil engineering community from 50 major, doctoral-granting institutions, with 5 schools examined in detail. Important questions are raised as to how funding patterns relate to rank and sub-discipline within Civil Engineering, and whether there is a causal link with publication rates. The paper presents key parameters with respect to issues that may be critical for tenure decisions at some institutions. They include total average number of awards per individual, the size of those awards normalized by named participant, and how these values have changed over the past nearly 40 years. These issues are considered for Geotechnical Engineering in comparison to other sub-disciplines within Civil Engineering. Funding breakdowns shows a higher reliance of Geotechnical engineers on traditional funding programs within NSF with a profoundly greater capacity to raise money at more senior levels, although these additional resources do not necessarily translate into increased journal publication rates.

INTRODUCTION

The highly competitive nature of obtaining tenure and subsequent promotion to Full Professor and the absence of prescriptive guidelines at most American institutions allow the topics of achievement and external recognition (two hallmarks of the process) to be interpreted by the various Tenure and Promotion (T&P) committees within each institution. At many institutions, National Science Funding (NSF) is considered one of these hallmarks, similar to peer-reviewed papers. This is because of the dual function of the highly peer-reviewed nature of the funding process (typically a minimum of 8 reviewers on an NSF panel) and the extremely competitive nature of the funding in Civil Engineering, at least in recent years. Anecdotal evidence would indicate funding rates of no higher than 10% for most major funding programs. This paper is designed to help provide the data necessary to help ascertain NSF funding trends within Civil Engineering, with particular attention paid to Geotechnical Engineers.

SCOPE OF STUDY

This study included a selection of highly research-active programs in the United States (US), as informed by listings on Compendex, ISI Web of Knowledge, and U.S. News and World Report rankings. Only institutions offering doctoral degrees were considered. In total, 50 were selected as listed in Table 1. Of these 32% were private and 68% public. Of the public universities, most are their state's flagship school. In some cases there is no representation for a particular state. The intent was to have a broad cross-section of Tier 1 and Tier 2 research schools.

Table 1. Institutions considered in the study by state and funding source.

State	Public	Private
Alabama	- Auburn Univ.	
Arizona	- Arizona State Univ.	
California	- Univ. of California (UC) Berkeley - UC Davis - UC Irvine - UC Los Angeles - UC San Diego	- California Institute of Technology (Caltech) - Stanford Univ.
Colorado	- Colorado School of Mines - Univ. of Colorado, Boulder	
Florida	- Univ. of Florida, Gainseville	
Georgia	- Georgia Institute of Technology (Georgia Tech)	
Illinois	- Univ. of Illinois at Urbana-Champaign	- Northwestern Univ.
Indiana	- Purdue	- Notre Dame Univ.
Iowa	- Univ. of Iowa	
Maryland	- Univ. of Maryland, College Park	- Johns Hopkins Univ.
Massachusetts	- Univ. of Massachusetts, Amherst	- Massachusetts Inst. of Tech. (MIT) - Tufts
Michigan	- Michigan State Univ. - Univ. of Michigan	
Minnesota	- Univ. of Minnesota	
Missouri		- Washington Univ. in St. Louis
New Jersey		- Princeton
New York	- Cornell University - SUNY Buffalo	- Columbia Univ. - Rensselaer Polytechnic Institute
North Carolina	- North Carolina State University	- Duke
Ohio	- Ohio State Univ. - Ohio Univ.	
Oregon	- Oregon State Univ.	
Pennsylvania	- Pennsylvania State Univ.	- Carnegie Melon Univ. - Drexel Univ. - Lehigh Univ.
South Carolina	- Univ. of South Carolina - Clemson (Univ. South Carolina)	
Texas	- Texas A&M University - Univ. of Texas, Austin	- Rice Univ.
Virginia	- Virginia Institute of Technology (Virginia Tech) - University of Virginia	
Washington	- University of Washington	
Wisconsin	- University of Wisconsin, Madison	

The study began in the summer of 2006 and all data should be considered as reflective of the state of the community in December 2006; the project's scale has required this long period to complete data collection. Initially, the web pages for the selected schools were used as the basis to identify faculty members who were either tenured or tenure-track, at each department. Information was collected from departmental and personal websites, as well as other professional listings, reports and publications. Missing personal data were solicited directly from the individual faculty members and their departments and obtained through official institutional publications, such as ABET self-study reports. Data related to research output was collected including all journal papers that appeared in Compendex with a date of 2006 or earlier. Information on co-authors, the publication year, and the impact factor of the respective journal in 2006 was also collected (preliminary analysis of that data is published in Laefer and McHale 2010). Additionally, information about grants awarded from the National Science Foundation was collated, including the type of program, and the number of co-applicants on the grant. This last section of data will form the basis for most of the analysis in this paper.

RESULTS

General Comments

Of the 50 universities examined, there were 1,313 permanent, tenured or tenure-track faculty members, of which 154 were Geotechnical (Table 2). A sub-discipline breakdown of the total pool is shown in Figure 1 (as determined either in departmental designation or through an examination of publication titles and teaching responsibilities).

Table 2. Study pool by rank

Rank	Total Individuals in Pool (% of total)	Geotechnical Faculty in Pool (% of total)
Assistant Professors	271 (20.6%)	25(16.2%)
Associate Professors	342 (26.1%)	46(29.9%)
Full Professors	687 (52.3%)	83(53.9%)
Faculty members with unknown rank	13 (1.0%)	0 (0%)
Total	1,313 (100%)	154 (100%)

Community Breakdown

For 1,284 (97.05%) of the individuals, their academic rank and area of subspecialization were known. Of them, approximately one-quarter each was working in either the Structural (25.78%) or the Environmental (24.61%) areas, respectively. A further third were nearly evenly distributed amongst Geotechnical (11.99%), Transportation (11.76%) and Hydrology (10.90%). The rest were working in Construction (6.39%), Materials (4.05%), Systems (2.88%), and Coastal (1.64%) (Fig. 1). Of these 1,284 faculty members, only 12.4% (159) were female. Most of the women were working in Environmental (21% female), with 13% working in Systems and all others 8%-12% women. The gender split for each area is shown in Fig. 2 by subdiscipline.

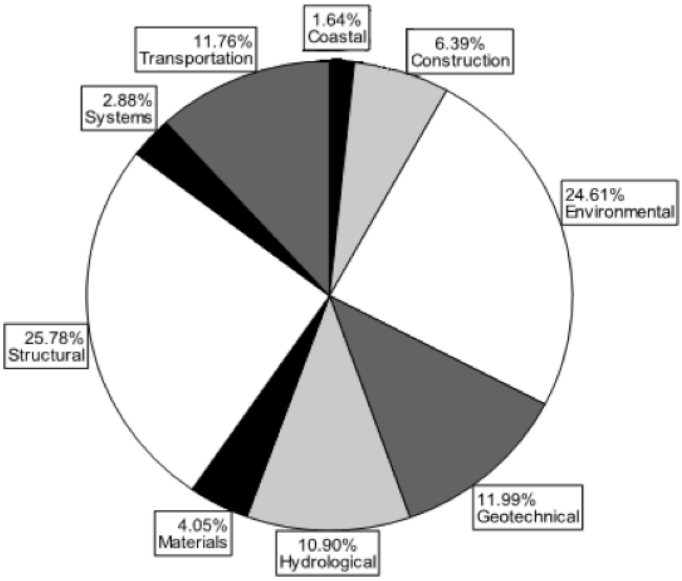


Fig. 1. Civil Engineering by sub-discipline as percentage of total study group

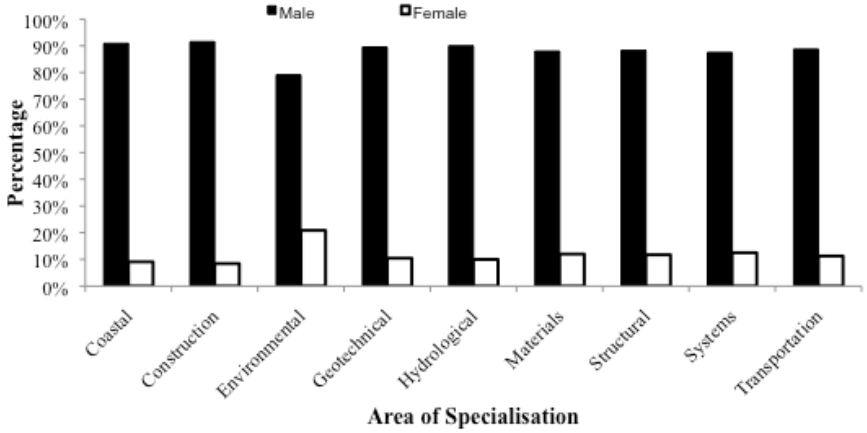


Figure 2. Faculty members by sub-discipline and gender

FUNDING

While NSF funding has greatly expanded over the decades (Fig. 3), so has pressure for that money, both in terms of the number of researchers competing for that money and the overhead rates that must be accommodated within that. Furthermore, while funding to the Engineering Directorate has increased quite substantially, funds for Civil and Mechanical Systems division (shown as Civil on Fig. 3) has largely been flat. The apparent increase in 2005 was only due to a merger with the Manufacturing Innovation program (forming CMMI) and is not a real increase.

Using non-inflation adjusted data, within the study group from 1970 to 2006, a total of 4,942 grants were awarded from Civil Engineering representing $2,150,513,151 with an average award size of $435,150, with an average total annual disbursement of $58,121,977. The money was distributed over 7,377 Principal Investigators (PIs) and collaborators (many outside the study group), resulting in $291,516 per listed participant (e.g. co-PIs and collaborators), as there was an average of 0.49

other participants per grant. Of the 1,313 faculty members in the study group, 940 (71.59%) were listed as either a (PI) or co-PI on at least one grant in the period.

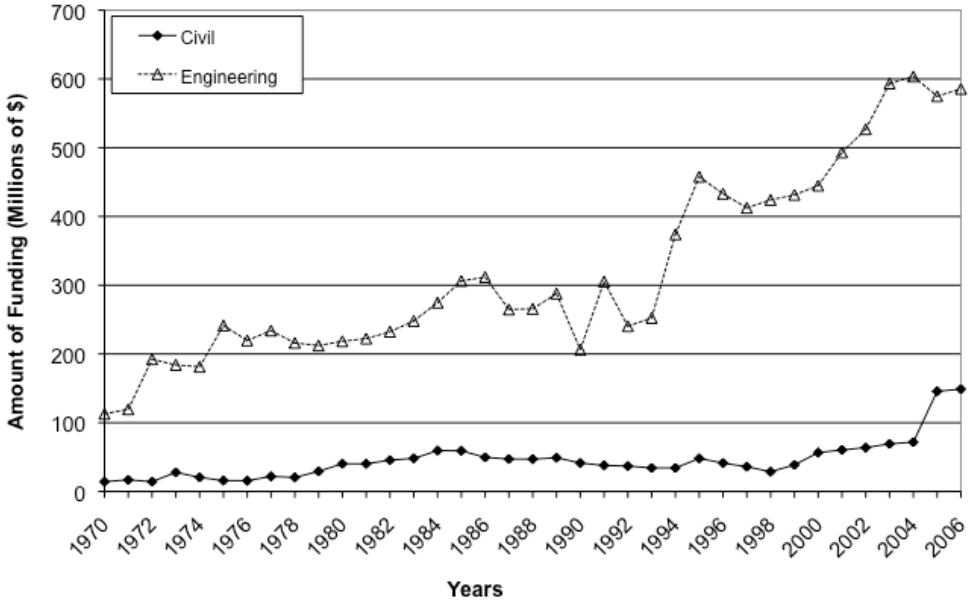


Figure 3. NSF Budgets for Engineering and Civil 1970-2006
[data provided by NSF, adjusted to 2006 dollars using (Sahr, 2010)].

Breakdown by Sub-specialization

Within NSF, various funding initiatives have been launched over the decades. One of the largest with respect to Civil Engineering was the National Earthquake Experimentation Sites (NEES) [NSF 2010]. Although there has been participation from those outside of Structural Engineering, the structural engineers benefited disproportionately from this effort, as shown in Fig. 4; because of the lumped reporting approach by NSF, further disaggregation and related analysis was not achievable. Of the 3 subdisciplines that have approximately the same number of faculty members (geotechnical, hydrological, and transportation – see Fig. 1), the geotechnical group obtained less NSF funding than the hydrological one, but substantially more transportation-area colleagues. This may strongly indicate that the transportation community receives the majority of its funding elsewhere (likely through state-based departments of transportation).

To compare Geotechnical funding levels versus those in Civil Engineering in general in terms of total funds and funds per investigator, 5 highly competitive universities were investigated in depth (Stanford, MIT, University of Illinois at Urbana-Champaign, University of Texas at Austin, University of California Berkeley). This sub-study involved 210 faculty members: 39 assistant professors (2 in geotechnics); 44 associate professors (5 in geotechnics) and 127 full professors (14 in geotechnics). Figure 5 shows NSF funds received for these 210 individuals.

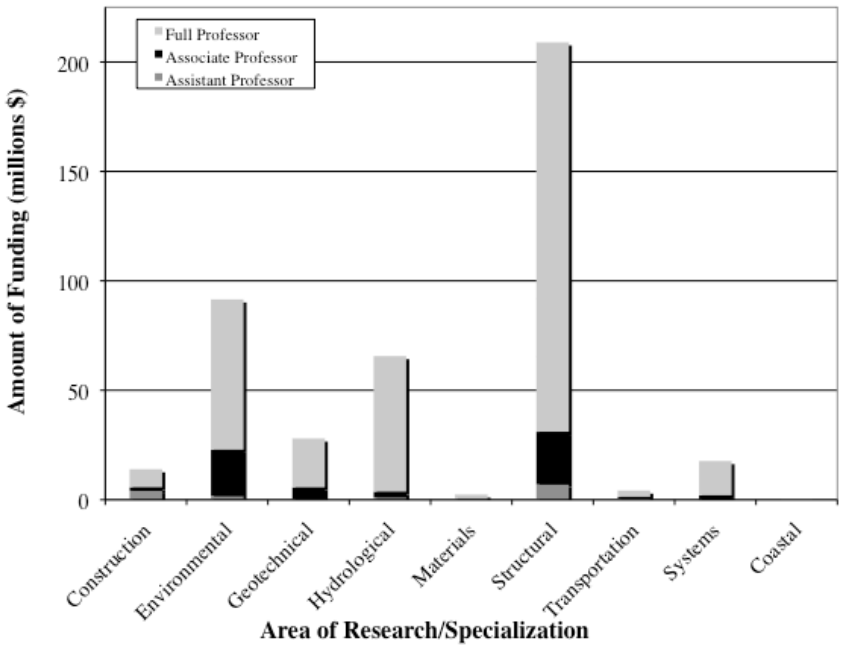
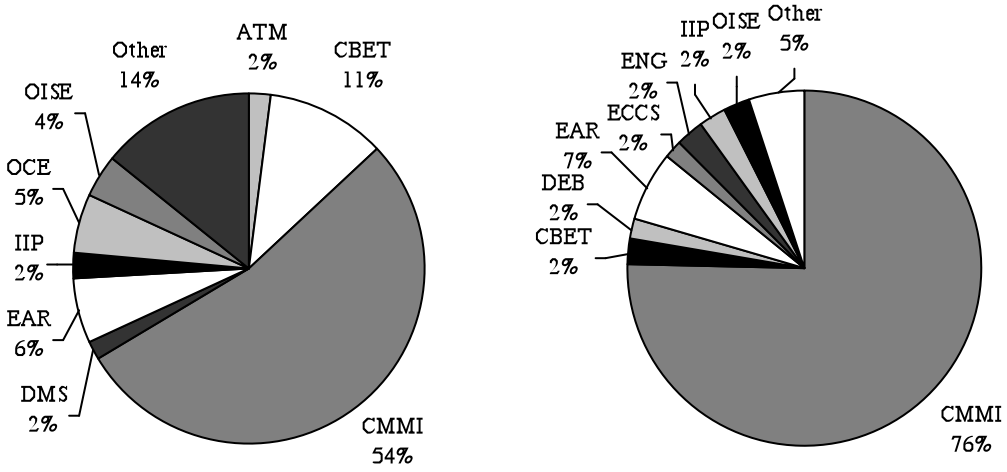


Figure. 4. Non-inflation-adjusted NSF funding 1970-2006 awarded to 5 university subgroup (full professors shown as top group).



(a) For Civil Engineering (b) For Geotechnical Engineering

Figure 5. Data from Fig. 4 disaggregated by NSF program (annotated in Table 3) for 5 university subgroup

There has been a heavier reliance by geotechnical engineers on traditional civil engineering funding (CMMI), accounting for 76% of their funding versus only 54% for the larger civil engineering community. Figure 6 shows year-by-year NSF funding awards to the 210 faculty members in the smaller study group. Figure 7 shows fig. 6 data normalized by number of collaborators – Geotechnical faculty members are getting smaller awards than the community average but when the money is split amongst co-PIs and collaborators, values are largely indistinguishable.

Table 3. Annotation of Fig. 5

	Name of NSF Division
ATM	Division of Atmospheric Sciences
CBET	Chemical, Bioengineering, Environmental and Transport Systems
CMMI	Civil, Mechanical and Manufacturing Innovation
DEB	Division of Environmental Biology
DMS	Division of Mathematical Sciences
EAR	Division of Earth Sciences
ECCS	Electrical, Communications and Cyber Systems
ENG	Office of Engineering
IIP	Industrial Innovation and Partnerships
OCE	Division of Ocean Sciences
OISE	Office of International Science and Engineering

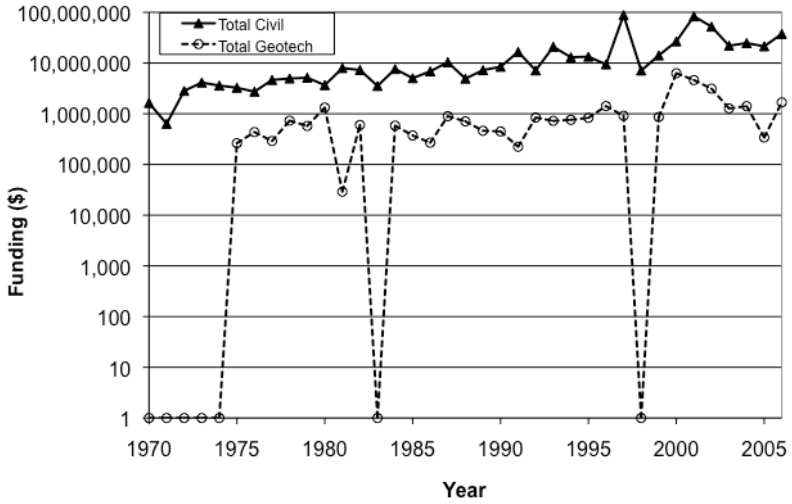


Fig. 6. Civil Engineering versus Geotechnical Engineering funding 1970-2006 by award for 5 university subgroup using inflation-adjusted data

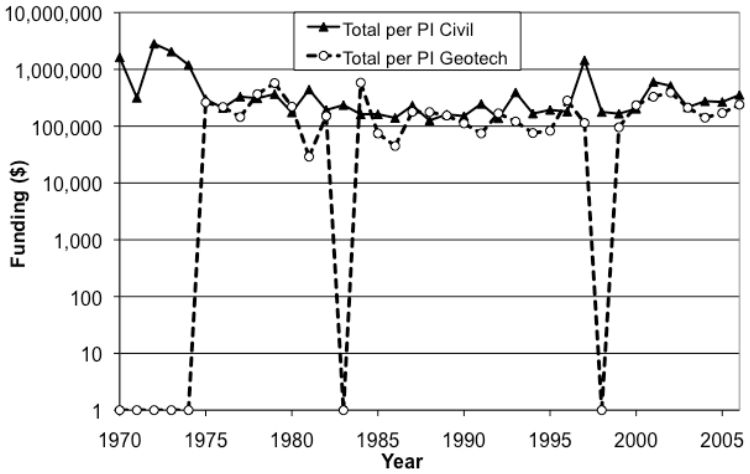


Fig. 7. Civil Engineering versus Geotechnical Engineering funding 1970-2006 normalized by number of collaborators for a 5 university subgroup using inflation adjusted data

Breakdown by Rank

The cumulative total awards of groups of individuals at specific ranks for the 5 universities in the subgroup are shown in Table 4. This shows that within the subgroup that Geotechnical faculty members were consistently more likely to take the leadership role of PI than the general pool.

Table 4. Total NSF funding awards (1970-2006) broken down by 2006 rank for the 5 university subgroup

Rank	All Disciplines PI awards	All Disciplines Co-PI awards	Geotech PI awards	Geotech Co- PI awards	All Disciplines PI/Co-PI	Geotechs PI/Co-PI
Assistant Prof.	164	48	30	6	3.42	5.00
Associate Prof.	153	58	12	4	2.64	3.00
Full Professor	294	104	43	9	2.83	4.78

When these data are further disaggregated by rank (as shown in Table 5), the Geotechnical community appears a bit older on average (at all ranks) than their general Civil Engineering colleagues based on years since award of doctorate; a fact noted previously as a concern for succession planning by Laefer and McHale (2010). At the assistant and full professor levels, the geotechnical engineering faculty members are bringing in smaller awards than others (52% and 39%, respectively). At the associate professor level the trend is reversed, with geotechs garnering 1.58 times the average award. When total funding is divided by all 210 members of the study group (instead of only those that received funding), the assistant and full professor levels improves to 63% and 51%, respectively, with the associate professors being almost identical (1.56 times). This indicates a higher percentage of geotechs with NSF funding than the general community. However, when the funding levels are divided by the number of collaborators and the years since Ph.D., the available resources are greatly diminished as function of both the relatively longer career spans in geotechnical engineering at the assistant and full professor levels. Those that got awards were more experienced than the general study group (Table 5 vs Table 6). In all cases, the number of years since award of doctorate was greater than those without NSF funding.

Table 5. NSF average inflation adjusted award amounts by 2006 rank for the 5 university study subgroup

Rank	Average PI award ($)	Average funding/total study group member ($)	Average number of co-PIs and collaborators per award	Average years since Ph.D.	Average award amount /[yr since Ph.D. * (team members)] ($)
Assistant Prof.	1,084,808 [562,075]	445,049 [281,038]	0.86 [1.52]	6.32 [8.08]	92,283 [27,605]
Associate Prof.	2,446,185 [3,888,833]	1,290,268 [2,010,598]	1.88 [2.30]	12.8 [14.88]	66,357 [79, 196]
Full Prof.	6,659,271 [2,600,583]	3,834,871 [1,938,891]	2.96 [2.78]	25.61 [26.06]	65,663 [26,400]

*[geotechnical faculty member awards]

Table 6. Award Rates by Rank for PI Awards across entire 5 university study sub-group

Rank	Average # of PI awards while Asst. Prof. /average size of award*	Average # of PI awards while Assoc. Prof. /average size of award*	Average # of PI awards while Full Prof.*	Total average years since Ph.D.**	Total average years on faculty**
Assistant Prof.	0.5/$13,419			5.5	4.5
Associate Prof.	3.5/$92,827	0.5/$105,376		13.5	9.5
Full Prof.	1.5/$160,915	0.8/$198,237	3.3/$203,281	24.9	24.3

*Normalized by number of collaborators

** Includes those with and without NSF funding

Table 7. Award Rates by Rank for Collaborator or Co-PI Awards

Rank	Average # of collaborator awards while Asst. Prof./ average size of award *	Average # of collaborator awards while Assoc. Prof./ average size of award *	Average # of collaborator awards while Full Prof./ average size of award *	Total average years since Ph.D.**	Total average years on faculty**
Assistant Prof.	0.5/$45,897			5.5	4.5
Associate Prof.	0/0	0/0		13.5	9.5
Full Prof.	0.2/$90,119	0.3/$203,525	0.9/$155,722	24.9	24.3

*Normalized by number of collaborators

** Includes those with and without NSF funding

Table 8. Journal Publication Rates by Rank for All Geotechnical Engineers in Full Data Set (Laefer and McHale, 2010).

Rank	Average annual number of papers as an Asst. Prof.	Average annual number of papers while Assoc. Prof.	Average annual number papers while Full Prof.	Total average years since Ph.D.	Total average years on faculty
Assistant Prof.	1.53			6.20	3.58
Associate Prof.	1.48	2.11		15.20	12.78
Full Prof.	0.38	0.50	0.58	26.71	25.21

With respect to considering this data in terms of tenure and promotion decisions the data can be further disaggregated, in terms of funds awarded during each period of the faculty members' careers (Tables 6 and 7). This shows that only half the assistant professors, who were on average fairly close to submitting their tenure packages (typically during year 5 or 6), had been awarded funding as a PI (Table 6) and an equal percentage as a co-PI or collaborator (Table 7). The associate professors in the group obtained 3.5 PI awards during their time as assistant professors, which was more than double that obtained by the Full professors during their time as assistant professors, even when the co-PI and collaborator awards were also added. The implication is that there is an increasing expectation and/or need for funding than in previous years and that the competitiveness for current funds is extremely high as evidenced by the award amounts for current assistant professors versus that obtained by the current associate professors when they were assistant professors. The issue of creeping expectations and/or enhanced performance amongst junior staff is some-

thing that has been documented in the Geotechnical community amongst the 154 faculty members in the larger data set, where annual publication rates are steadily increasing (Table 8). Tables 6-8 also show that as individuals gain rank there is a correlation with both greater research funding and greater productivity, but that those at lower ranks are generating significantly more journal papers than their more senior colleagues, albeit that this is only one way to measure productivity.

CONCLUSION

Geotechnical faculty members have a disproportionately high reliance on obtaining NSF funding from the CMMI program and are in part, as a function of this, not as successful (on an annual basis) in getting as many awards or as much money as areas such as Structures. Examination of other funding sources (e.g. Environmental Protection Agency, Department of Defense, state-level Department of Transportation) is needed to further explore this issue. Funding rates at five highly competitive schools would indicate a fairly senior community, with increasing NSF funding success per rank. However, this increased access to funding does not seem to directly correlate to peer-reviewed journal papers. Other means of dissemination (e.g. patents, books) and other measures (e.g. citation rates and citation cycles) need to be explored to understand what seems to be a disjunct between resources and productivity.

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