APPENDIX D

A NOTE ON THE RANKING OF FEMALE ACADEMICS IN CIVIL ENGINEERING DEPARTMENTS SPECIALIZING IN MECHANICS AND EARTHQUAKE ENGINEERING

1. Introduction

About one third of both undergraduate and graduate students at American universities are female. As it has become recognized that women faculty, serving as role models, help increase the recruitment as well as the retention of female engineering students, many schools have made an effort recently to hire women faculty. Many schools have started this hiring process only about 10 years ago.

While the percentage of females among all professionals has increased from about 37% in 1984 to almost 50% in 2000, at universities the percentage of female faculty continues to be small. Between 1984 and 1990, it increased only from 25 to 27 percent, although it experienced somewhat faster growth (from 27% to 37%) between 1990 and 1996. Since 1996, it has remained almost constant, between 36 and 37 percent (Fig. D.l (top); p. 28 of March 2002 issue of *Academe*).

A survey of engineering faculty at 236 American colleges and universities for the period 1996 – 2001 showed that at more than half (54 percent) of all institutions, the number of female engineering faculty (FEF) has either decreased or remained the same. Although at 18 institutions (8%) the number of female faculty has doubled and at 22 institutions (9%) the increase was even larger, the majority of the institutions reporting large percentage increases between 1996 and 2001 had only 1 or 2 female faculty members in 1996. Table D.1 lists 23 universities with more than 10 FEF, and the respective increases in 2001. At eight of these institutions, the increase was equal to or greater than 50%.

In this study, we analyze the performance of a sample of female faculty in civil engineering, mechanics and earthquake engineering at U.S. universities and compare them with selected male faculty members. Because complete lists of publications were not generally available to us for faculty at other universities, we used the Earthquake Engineering Abstracts (EEA) database of the National Information Center for Earthquake Engineering (NISEE) to estimate their *input* to the pool of scientific literature, and we used the cited articles in the Thomson ISI database to measure their successful *output*. The NISEE EEA database is at present the most complete source of information on published material in earthquake engineering and the related fields (mechanics, structural and geotechnical engineering, and materials science) worldwide. It contains over 100,000 records in mechanics, structural engineering, geotechnical engineering,

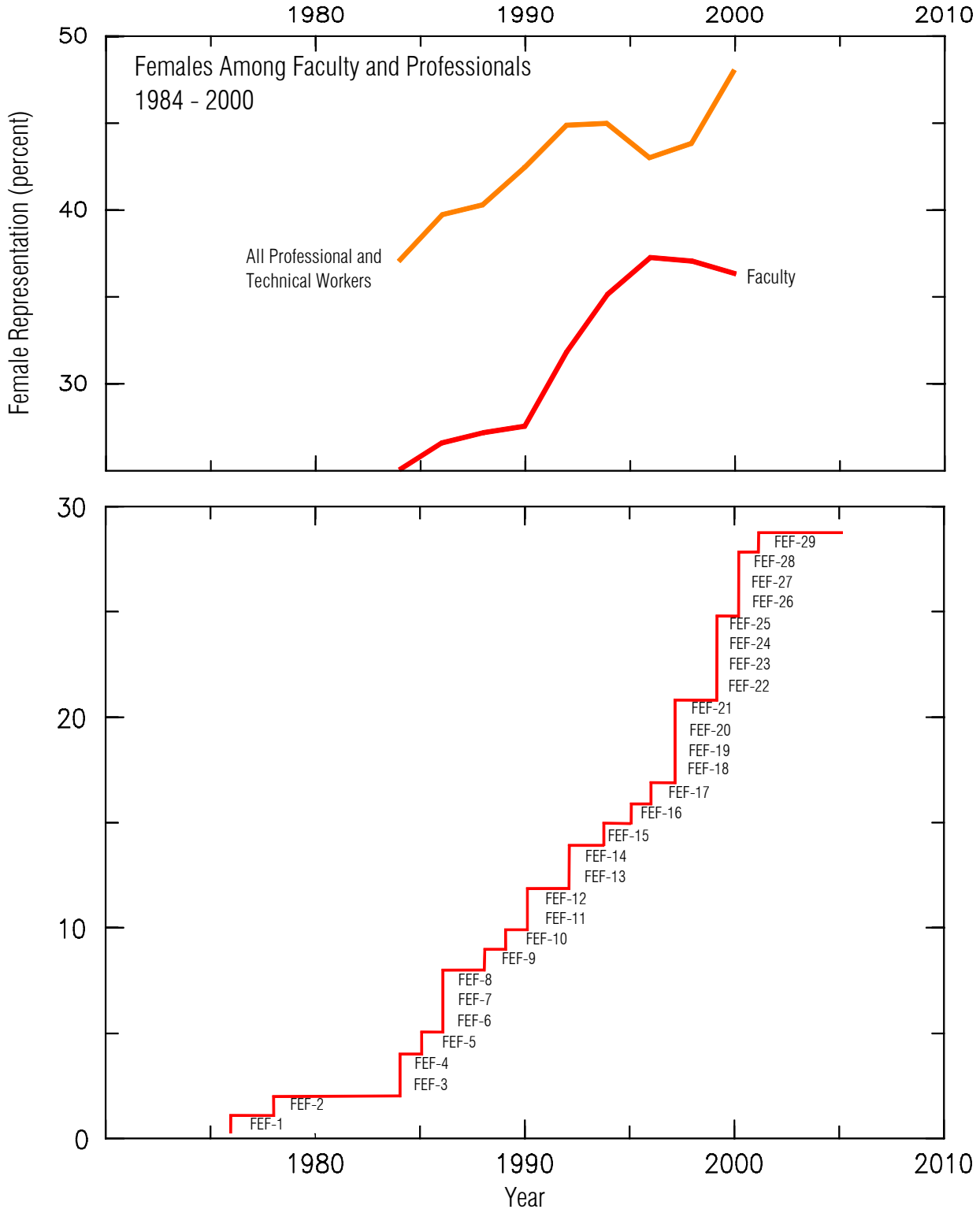

Fig. D. l: Percentage of females among all professional and technical workers and among faculty, versus time, for the period between 1984 and 2000 (top), and arrival times (year of Ph.D.) of 29 female faculty and researchers in the field of earthquake engineering and related fields (bottom) (see also Table D.3).

Table D.1. Increase in the Number of Female Engineering Faculty, 1996 to 2001, at Selected Institutions Reporting 10 or more Female Faculty in 1996

University	Number of Female faculty		Change	**% Change**
	1996	2001		
Arizona State University	**17**	**28**	**11**	**65**
Boston University	10	13	3	30
Carnegie Mellon University	**10**	**15**	**5**	**50**
Colorado School of Mines	20	22	2	10
Cornell University	**14**	**23**	**9**	**64**
Georgia Institute of Technology	**16**	**41**	**25**	**156**
Iowa State University	18	20	2	11
Massachusetts Institute of Technology	**25**	**38**	**13**	**52**
Mississippi State University	14	17	3	21
North Carolina State University	12	16	4	33
Northwestern University	14	18	4	29
Ohio State University	21	29	8	38
Purdue University	**20**	**31**	**11**	**55**
Stanford University	13	15	2	15
Texas A&M University	21	25	4	19
U. of Colorado, Boulder	**15**	**24**	**9**	**60**
U. of Illinois, Urbana	24	35	11	46
U. of Maryland, College Park	13	15	2	15
U. of Massachusetts	11	13	2	18
U. of Michigan	27	33	6	22
U. of Minnesota	27	31	4	15
U. of Texas, Austin	22	24	2	9
U. of Wisconsin, Madison	**11**	**19**	**8**	**73**

engineering seismology, and related fields since 1971. It includes most (but not all) contributions to the applied mechanics and earthquake engineering literature. With few exceptions, it can be assumed that the number of abstracts in this database represents a lower bound of the number of contributions of the sample studied in the fields of their specialization and into the related literature.

2. A Sample of Female Engineering Faculty and Researchers in Civil Engineering, Mechanics and Earthquake Engineering in the U.S.

To identify female engineering faculty (FEF) for our study, we surveyed the Web sites of civil engineering departments of about 40 universities in the U.S. and recorded the names and basic biographical information on the female faculty on the tenure track with expertise in the areas of mechanics, earthquake engineering, and related fields (geotechnical engineering, structural engineering, engineering seismology, and materials science), which excludes only the faculty in environmental engineering, transportation, and construction.

We first list in Table D.2 the 19 of the surveyed universities that did not have a female faculty on the tenure track in the fields of interest for this study. Next, in Table D.3, we list the FEF that we found. Columns (1) through (8) following the FEF number represent: (1) total number of abstracts in the NISEE database; (2) total number of ISI citations (as of January 10, 2004); (3) total number of cited articles (journal papers, reports, conference papers,...) in the ISI database; (4) year when Ph.D. was awarded; (5) number of years since Ph.D. degree; (6) average citation rate per cited article per year; (7) current position; and (8) areas of research. We have included in this sample one female faculty at USC who is on the research track and one senior female faculty in architecture at U.C. Berkeley. The list in Table D.3 contains the faculty who have a number of NISEE abstracts and ISI citations that are significant enough to present graphically in the further analysis. We found 17 other FEF, but we did not include them in Table D.3 because as of December 2003 they had only a few or no citations in the NISEE and ISI databases. In several instances, duplicate names and initials, combined with similar professional activities of different authors in the ISI database, made it difficult to separate the contributions of some female faculty listed in Table D.3. This has been indicated by "?" in this table. Fig. D. l (bottom) shows the year of Ph.D. degree for 29 FEF, and thus it approximates the time of beginning their careers.

For selected male and female faculty, detailed studies of the data from the ISI and NISEE databases have been carried out and are described elsewhere in this report. In this appendix, only the data on their total number of ISI citations, excluding self-citations, will be used.

Table D.2. A Sample List of Universities with No Female Faculty in Civil Engineering, Except Maybe in the Areas of Environment Engineering, Transportation Engineering and Construction Management

Caltech Duke U. M.I.T. Oregon State U. U. Central Florida U. Colorado at Boulder U. Illinois, Chicago U. Louisiana, Lafayette U. Michigan, Ann Arbor U. Nevada, Reno	U. North Florida U. Oklahoma U. South Florida (Tampa) U. Southern California U. Virginia U. Wisconsin, Milwaukee U.C. Davis U.C. Los Angeles U.C. San Diego

Figure D.2 shows a correlation plot of the cited articles in the ISI database and the number of NISEE abstracts, plotted on a logarithmic scale. It can be seen that FEF-14, FEF-13, FEF-6, FEF-7, and FEF-9 are above the 45-degree line. This implies that (1) most of their articles are in the NISEE database and (2) the percentage of their cited publications is high relative to those not cited. The other twelve points in Fig. 2 are 0.10 to 0.85 units below the 45-degree line, which corresponds to factors between 1.26 and 7.0 on the linear scale and implies that for these individuals one out of 1.26 to one out of 7 articles were cited. For FEF-5 and FEF-8, the number of NISEE abstracts appears to be anomalously low. The NISEE database includes most of the important and recognized contributions, but not all journal papers, reports, conference papers, workshop proceedings, pamphlets, books, etc., while the Thomson ISI database includes citations made from articles in only about 6,000 leading journals. Thus, a researcher who contributes many reports and conference articles will tend to have a "larger" NISEE total count and a "lower" Thomson ISI number of cited papers.

Figure D.3 shows, on a logarithmic scale, the total number of ISI citations as of January 2004 (see column (2) in Table D.3) versus the total number of articles in the NISEE database. As already shown in Table D.3, FEF-1 has the largest number of NISEE Abstracts (138), while FEF-9 has the largest number of ISI citations.

Fig. D.4 shows, on a logarithmic scale, the total number of ISI citations plotted versus the logarithm of the total number of cited articles in the ISI database. It can be seen that, in the majority of cases, for younger researchers there are about two citations per cited paper. After 15 to 20 years of contributions to the field, the average approaches 4 citations per cited paper. Within this group, FEF-4 has the highest citation rates per cited paper.

To eliminate the consequences of the length of observation (3 to 28 years, see Table D.3), we can compute the citation rate per cited paper per year (equal to the total number of ISI citations divided by the product of the number of cited papers and the number of years since award of Ph.D.). The results are shown in Fig. D.5. It can be seen that, in this sample, the citation rate is in the range from 0.111 (FEF-8) to 0.533 (FEF-25). These rates are also listed in column (6) of Table D.3. We note that six of the female faculty shown in Fig. D.5 are not considered in Figs. D.2 through D.4 because as of January 2004 they either did not have any NISEE abstracts (FEF-25, FEF-28, FEF-26, FEF-10), or had only two abstracts (FEF-16, FEF-17).

3. Comparison with Male Researchers

Figures D.6a,b, and c show the cumulative number of NISEE abstracts for selected leading male researchers in earthquake engineering. Figure D.7 shows the same for the faculty and researchers in the USC Civil Engineering Department. To facilitate relative comparison of Figures D.6b and D.7 with Figure D.6a, the upper (about ten papers per year) and lower (about one paper per year) bounds, determined by the curves in Fig. D.6a, are reproduced by wide lines. Figure D.8, plotted with the same scales as Fig. D.6b and D.7, shows the corresponding results for nine female faculty. It can be seen that some of the female faculty are as productive as the most active male faculty members (see also Fig. D.6a).

Figure D.9 compares male and female faculty by plotting the total number of ISI citations versus the total number of NISEE abstracts or equivalent (for M.A. Biot, 1905-1985, the father of earthquake engineering, the NISEE database is incomplete, and so the total number of his published papers—179— has been used instead). Fig. D.10 shows the corresponding rates, the average number of ISI citations per year, versus the average number of NISEE abstracts per year.

Figure D.10 shows that, for the female faculty listed in Table D.3, the typical number of contributed abstracts (*input* = 0.7 to 6 per year) and the typical number of citations per year (*output* = 0.7 to 30 per year) are smaller than those of their male counterparts (*input* = 1 to 8 abstracts per year, and *output* = 8 to 100 per year). However, these results cannot be interpreted to mean that on average female engineering faculty are not performing as well as their male counterparts (see Appendix C) because of the differences in size of the pool of male versus female faculty, differences in distribution over ranks, and the way we sampled the female versus male faculty. The pool of male faculty is orders of magnitude larger than the one of female faculty, even more so at the higher ranks (most female faculty were recent hires and many are only at the assistant professor rank). While our sample included most (if not all) female faculty in civil engineering, mechanics, and earthquake engineering at leading research universities in the U.S., in contrast, our sample of male faculty is neither exhaustive nor random. Except for the attempt to include as many as possible male counterparts from USC (USC-14, USC-9, USC-10,

Table D.3. Sample of Female Engineering Faculty and Researchers in Civil Engineering

Name	NISEE Total (1)	ISI Total Citations (2)	ISI Total Articles (3)	Year of Ph. D. and School (4)	Years Since Ph.D. (5)	(2)/(3)/(5) (6)	Current (Jan. 2004) Position (7)	Specialty and Areas of Research (8)
FEF-1	138	194	60	1976	28	0.115	Professor	Seismic hazard, loss estimation, earthquake engineering
FEF-2	35	16	9	--	--	--	Professor	Economic impacts of building codes, cost and benefits of rehabilitation of existing buildings
FEF-3	23	42	18	1984	20	0.117	Professor	Concrete and prestressed concrete structures, earthquake engineering
FEF-4	22	68	8	1984	20	0.425	Professor	Mechanics, structural analysis, reliability, seismic hazard, loss estimation
FEF-5	1	132	32	1985	19	0.217	Assoc. Prof.	Fiber-reinforced concrete, mechanical behavior, and toughening mechanisms
FEF-6	25	74	27	1986	18	0.152	Professor	Structural engineering, earthquake engineering
FEF-7	32	163	44	1986	18	0.206	Professor	Engineering seismology, earthquake engineering, probabilistic methods
FEF-8	3	24	12	1986	18	0.111	Professor	Evaluation of structures damaged by natural disasters, impact, or blast; historic structures
FEF-9	92	459(212)*	103	1988	16	0.278	Research Assoc. Prof.	Wave propagation, seismic hazard, soil-structure interaction, applications of wavelet representation in time-series analysis
FEF-10	--	32	14	1989	15	0.152	Assoc. Prof.	Geotechnical engineering, centrifuge modeling, porous media flow, and transport
FEF-11	2	167 (?)	8 (?)	1990	14	?	Assist Prof.	Failure analysis, localization and instabilities, micromechanical interactions of fluids and particles
FEF-12	22	63	18	1990	14	0.25	Assoc. Prof.	Nonlinear finite elements, structural dynamics, materials, constitutive modeling
FEF-13	19	70	31	1992	12	0.188	Professor	Experimental mechanics, structural dynamics, vibration control
FEF-14	8	28	12	1992	12	0.194	Assist. Prof.	Linear and nonlinear mechanics, finite elements, stability, vibration isolation
FEF-15	6	3	I	1994	10	0.3	Assoc. Prof.	Condition assessment for infrastructure systems, structural and earthquake engineering.

Name	NISEE Total (1)	ISI Total Citations (2)	ISI Total Articles (3)	Year of Ph. D. and School (4)	Years Since Ph.D. (5)	(2)/(3)/(5) (6)	Current (Jan. 2004) Position (7)	Specialty and Areas of Research (8)
FEF--16	2	25	6	1995	9	0.463	Assist. Prof.	Geotechnical engineering
FEF-17	2	15	7	1996	8	0.268	Assoc. Prof.	Stochastic finite elements, probabilistic mechanics, micromechanics
FEF-18	5	6	6	1997	7	0.143	Assist. Prof.	Advanced simulation, design and concrete structures, repair and rehabilitation, cement-based composites
FEF-19	9	38	12	1997	7	0.452	Assist. Prof.	Seismic response of earth structures, soil liquefaction, earthquake engineering
FEF-20	12	(?)	(?)	1997	7	---	Assist. Prof.	Earthquake risk, hurricane disasters
FEF-21	7	1	I	1997	7	0.143	Assist. Prof .	Performance-based design, earthquake response of concrete buildings, seismic performance of masonry buildings
FEF-22	7	9	4	1998	6	0.375		--
FEF-23	13	6	3	1998	6	0.333	Assist. Prof.	Seismic design, evaluation, and repair of concrete structures
FEF-24	13	12	5	1998	6	0.4	Assist. Prof.	Finite elements, non-linear analysis, constitutive theory
FEF-25	0	16	5	1998	6	0.533	Assist. Prof.,	Microstructure and durability of cement-based materials, fiber-cement composites
FEF-26	0	5	3	1999	5	0.333	Assist. Prof.	Cement-based materials
FEF-27	12	6	5	1999	5	0.24		Structural dynamics, vibration control, structural health monitoring, expert Systems
FEF-28	0	18	7	1999	5	0.514	Assist. Prof.	Seismic isolation, earthquake-resistant design, fluid structure interaction, free surface and oscillating biddies
FEF-29	3	0	0	2001	3	---	Assist. Prof.	Experimental and analytical studies in earthquake engineering, visualization, and virtual reality

( )* All self-citations excluded.

(?) Duplicate names—cannot separate without detailed analysis.

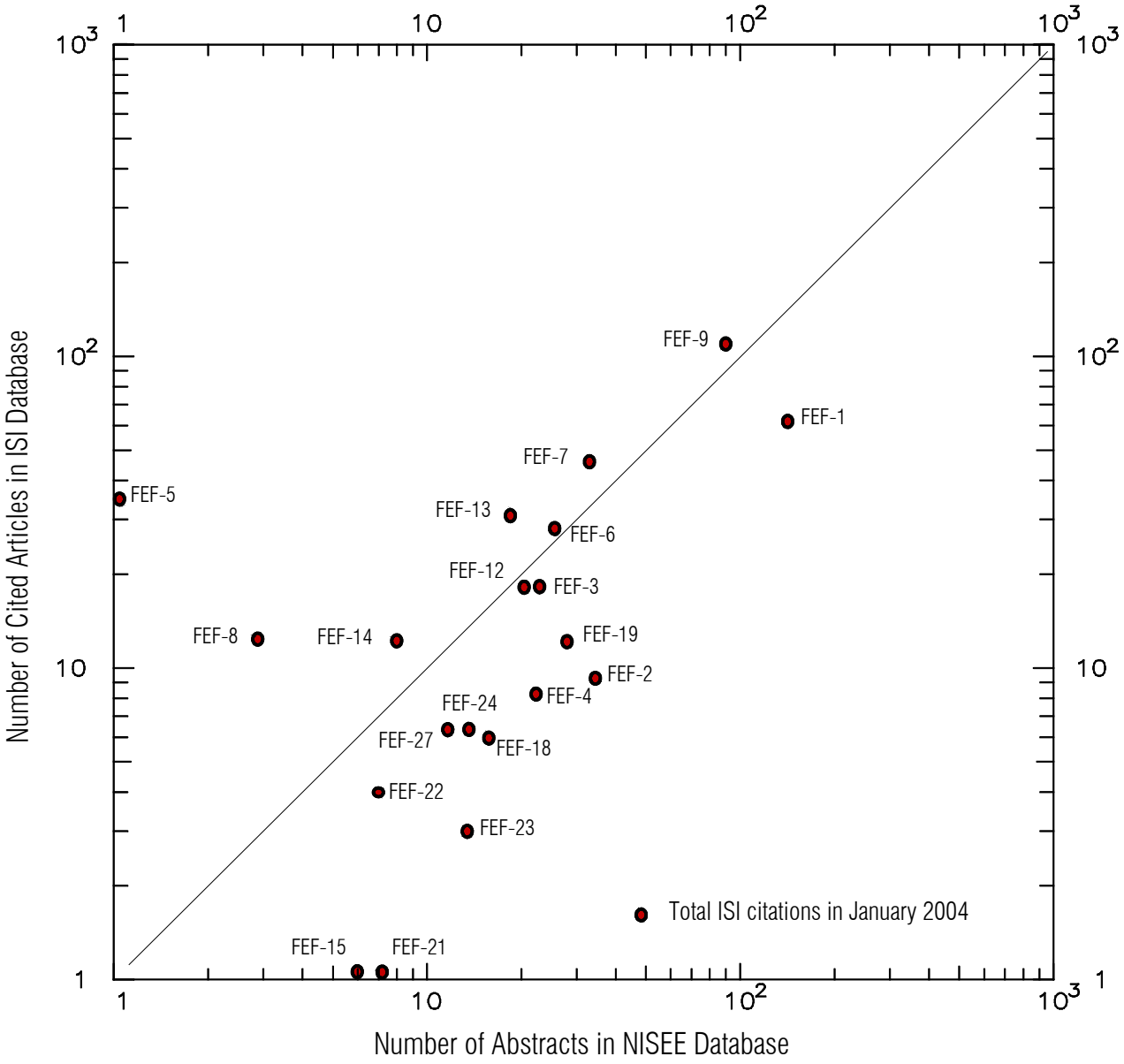

Fig. D.2: Number of cited articles in ISI database versus the number of articles in NISEE database.

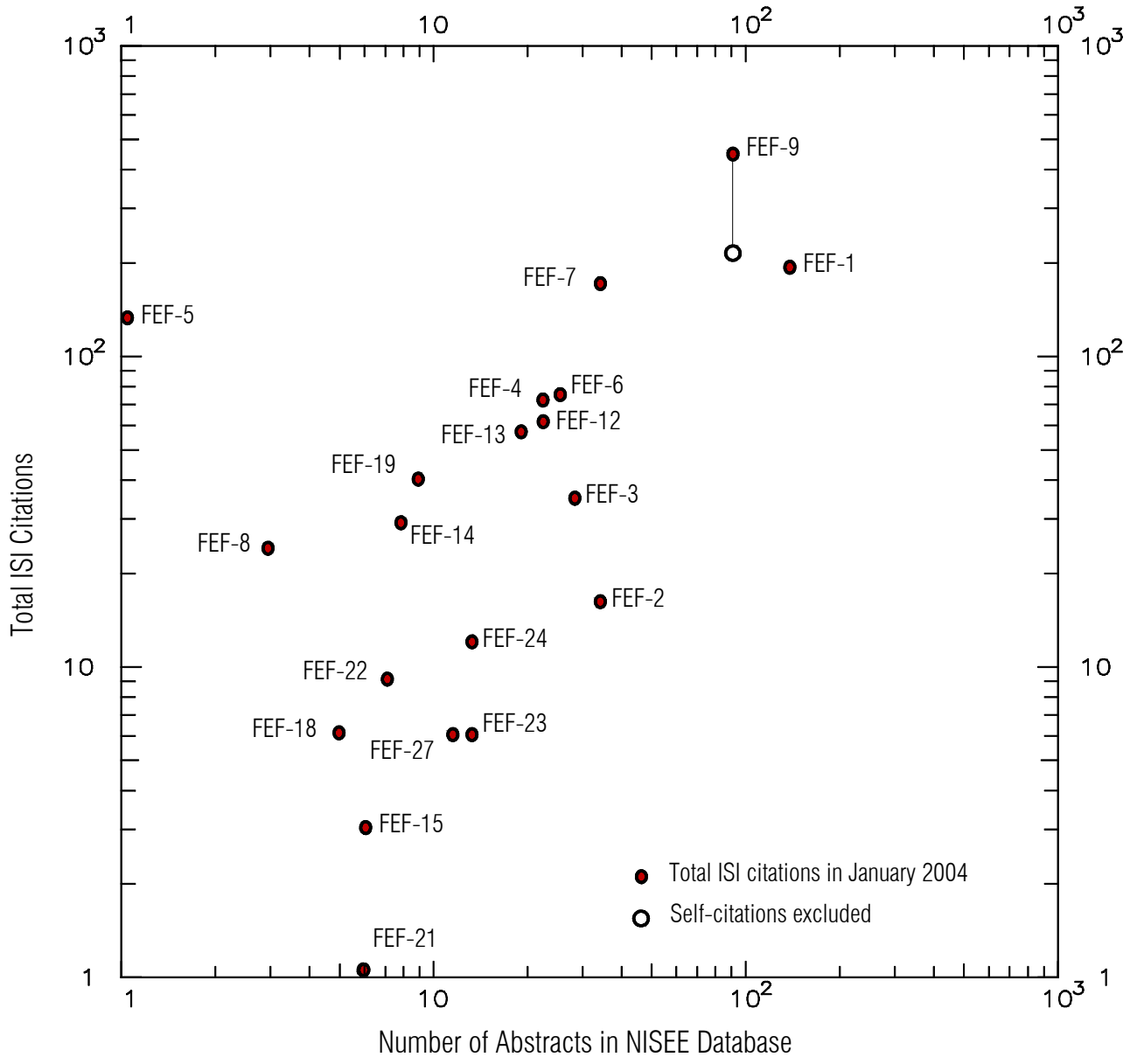

Fig. D.3: The total number ISI citations versus the number of abstracts in NISEE database.

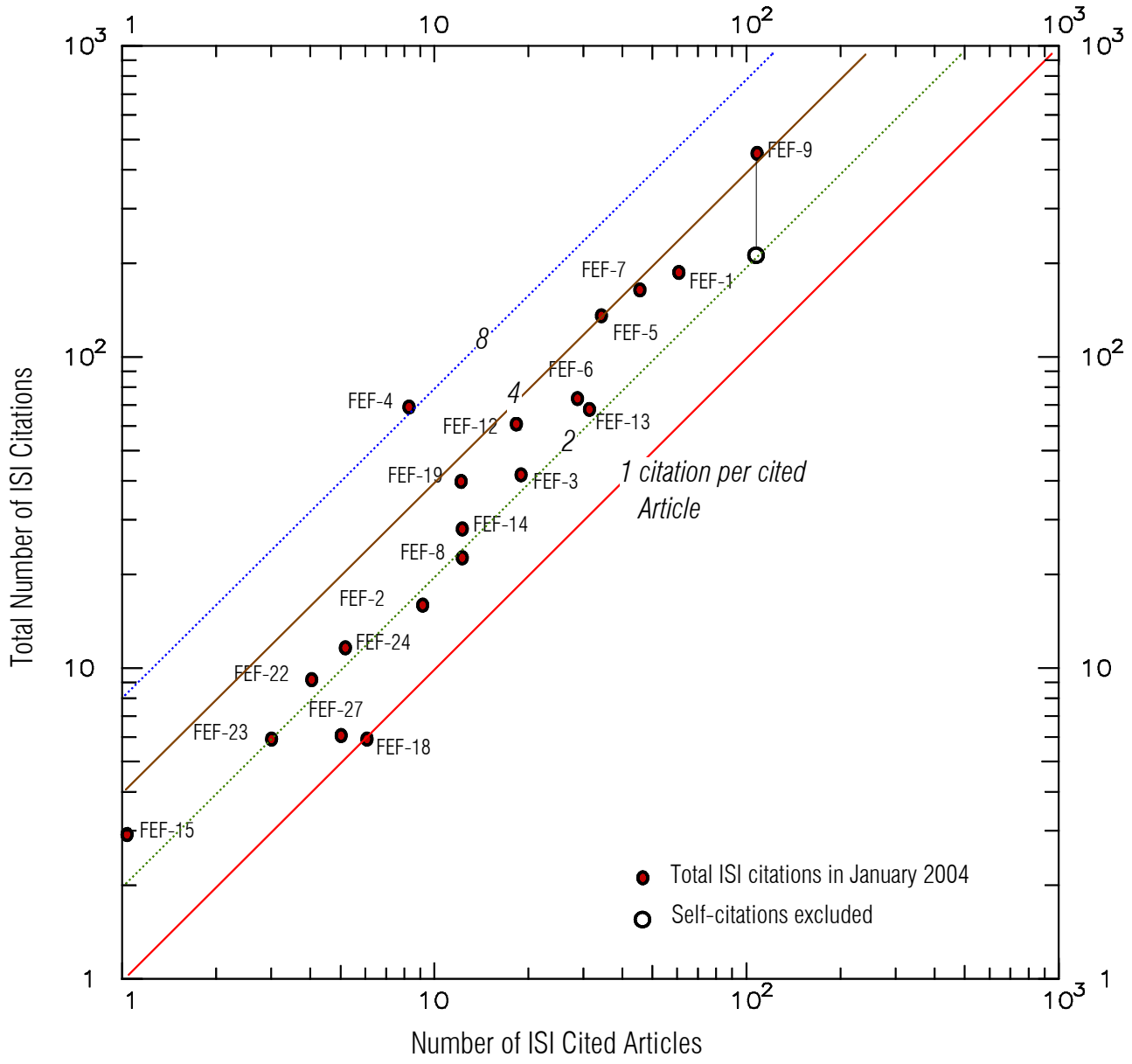

Fig. D.4: Total number of citations in the ISI database versus the number of cited articles.

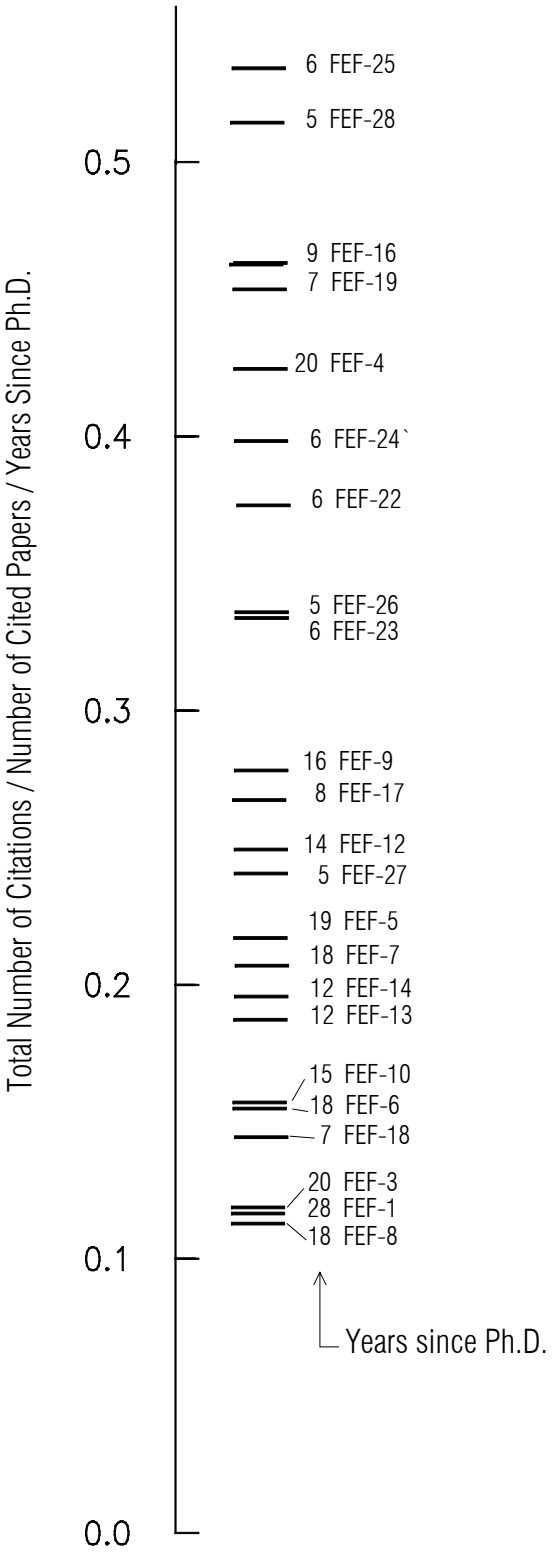

Fig. D.5: Total number of citations per cited paper per year (measured since the year of Ph.D.).

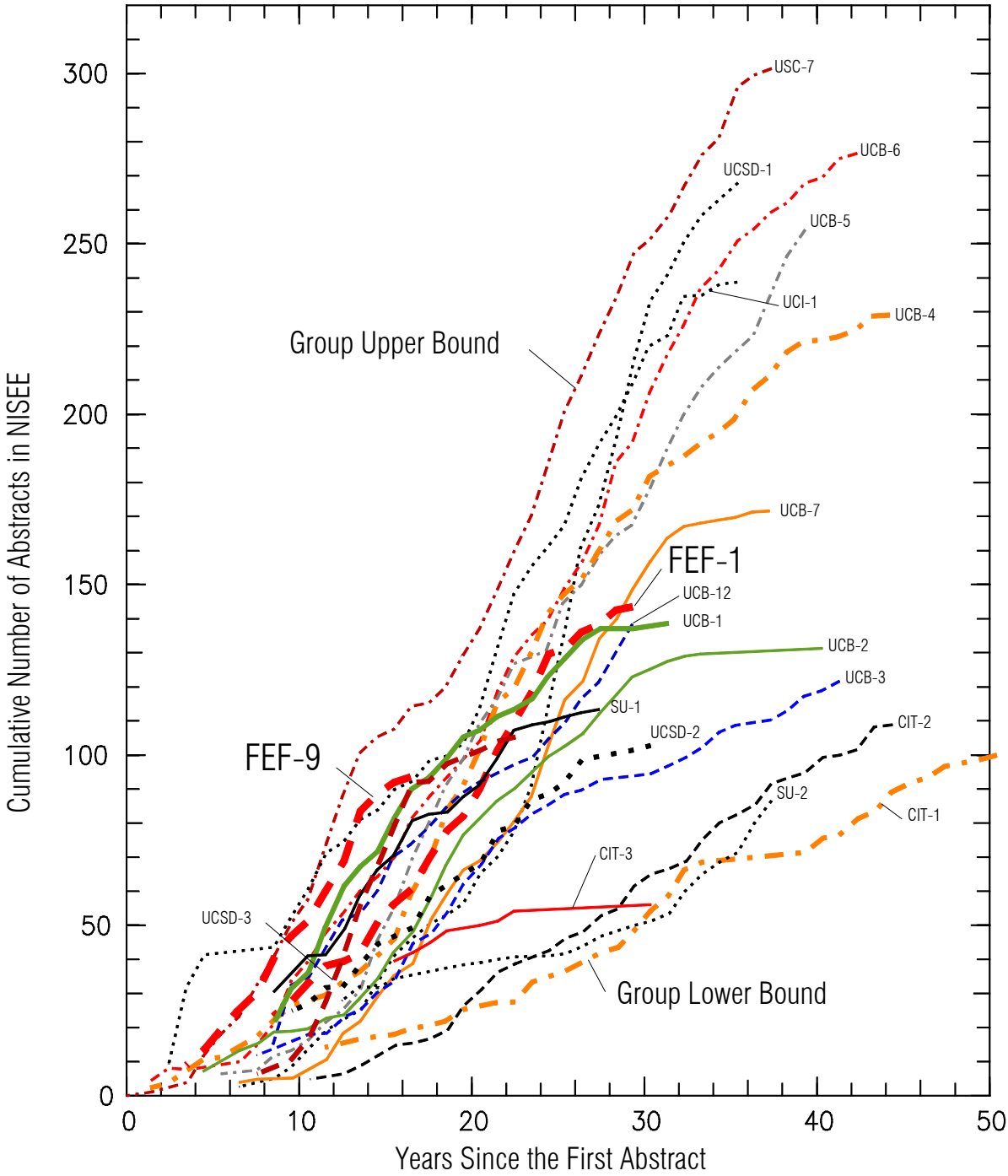

Fig. D.6a: Comparison of the cumulative number of published articles in the NISEE database versus time (in years since the first citation) for 18 male faculty and two female faculty in earthquake engineering (FEF-1 and FEF-9).

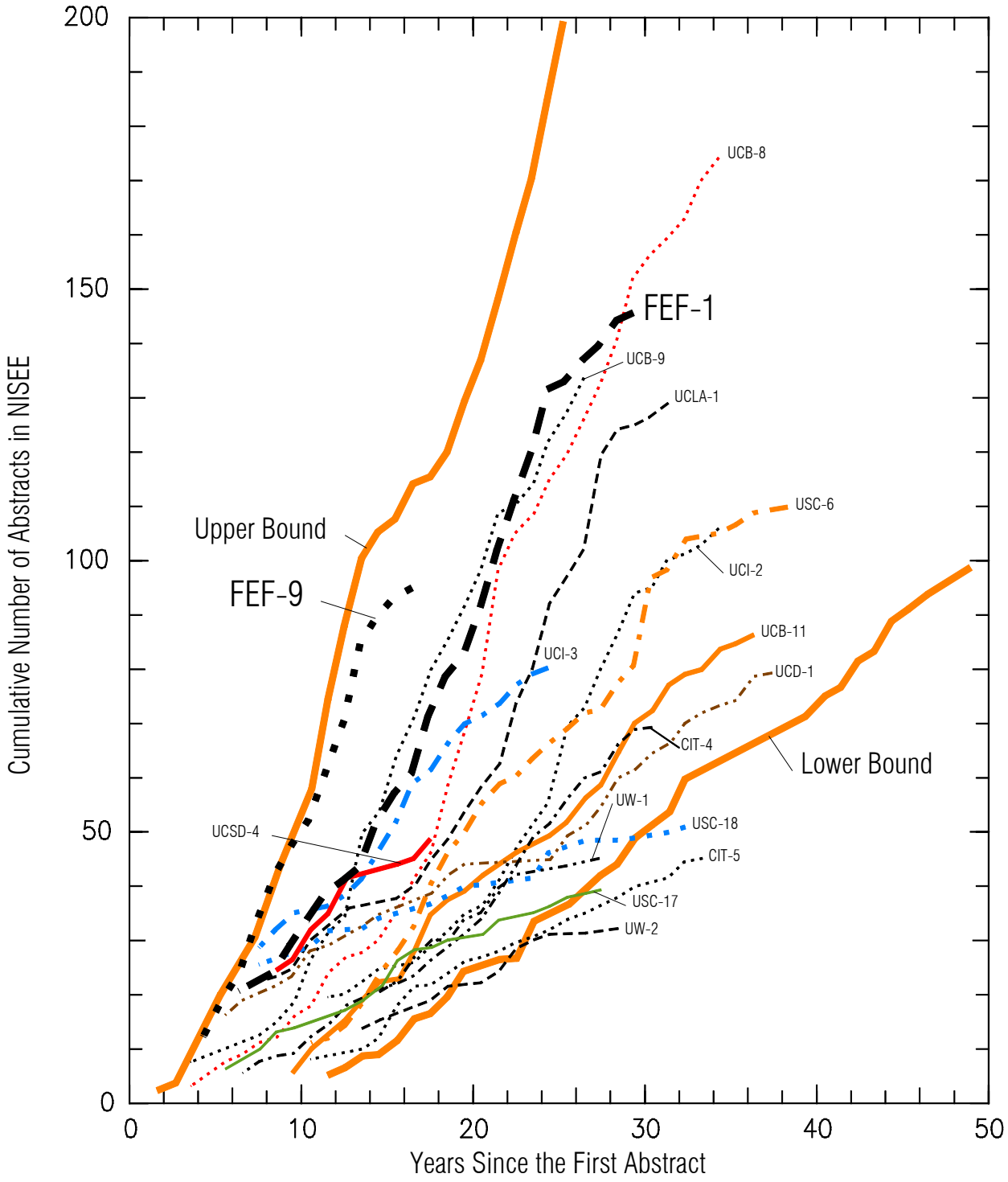

Fig. D.6b: Same as Fig. 6a, but for 15 different male faculty members.

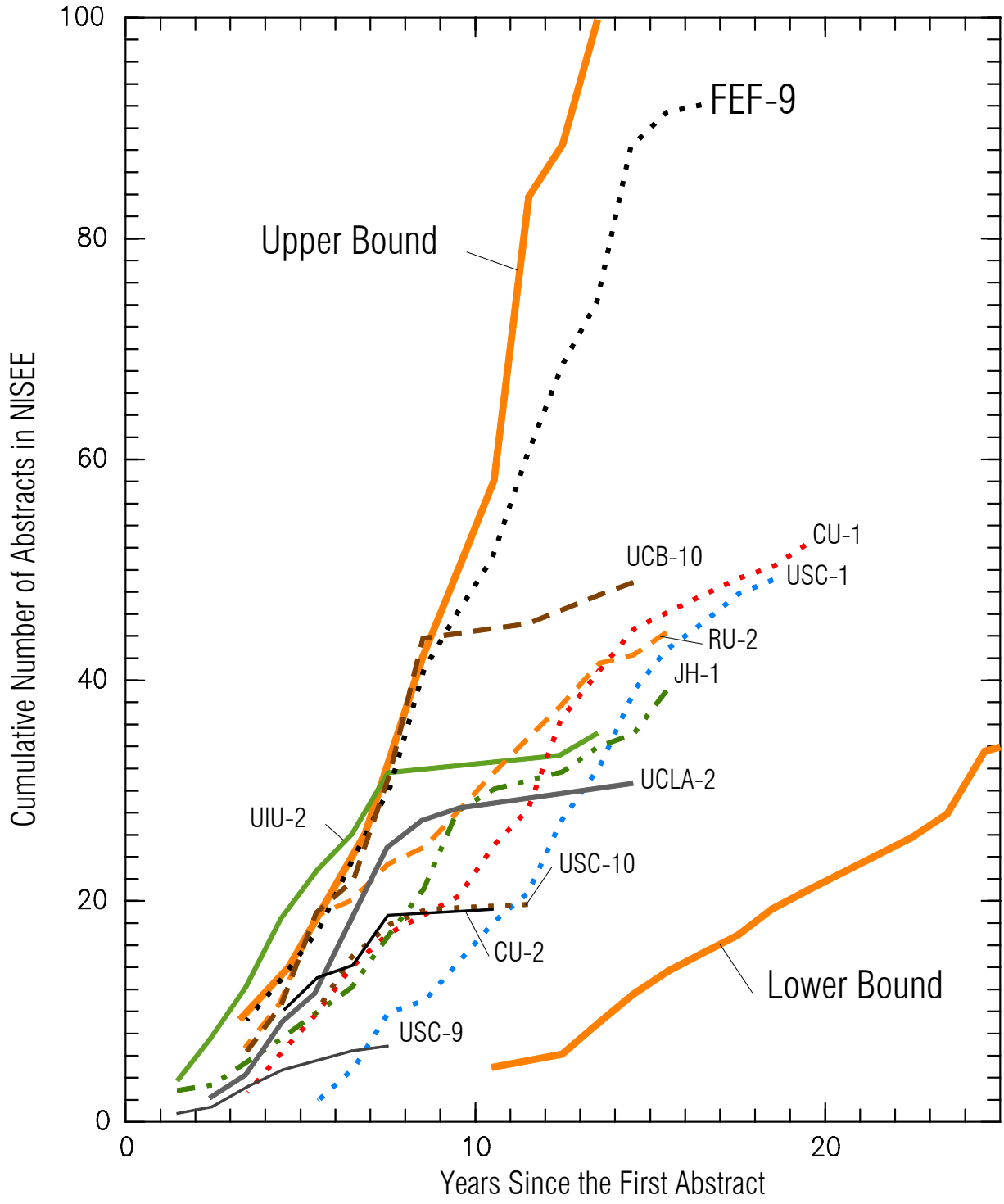

Fig. D.6c: Same as Fig. 6a, but for 11 "younger" academics.

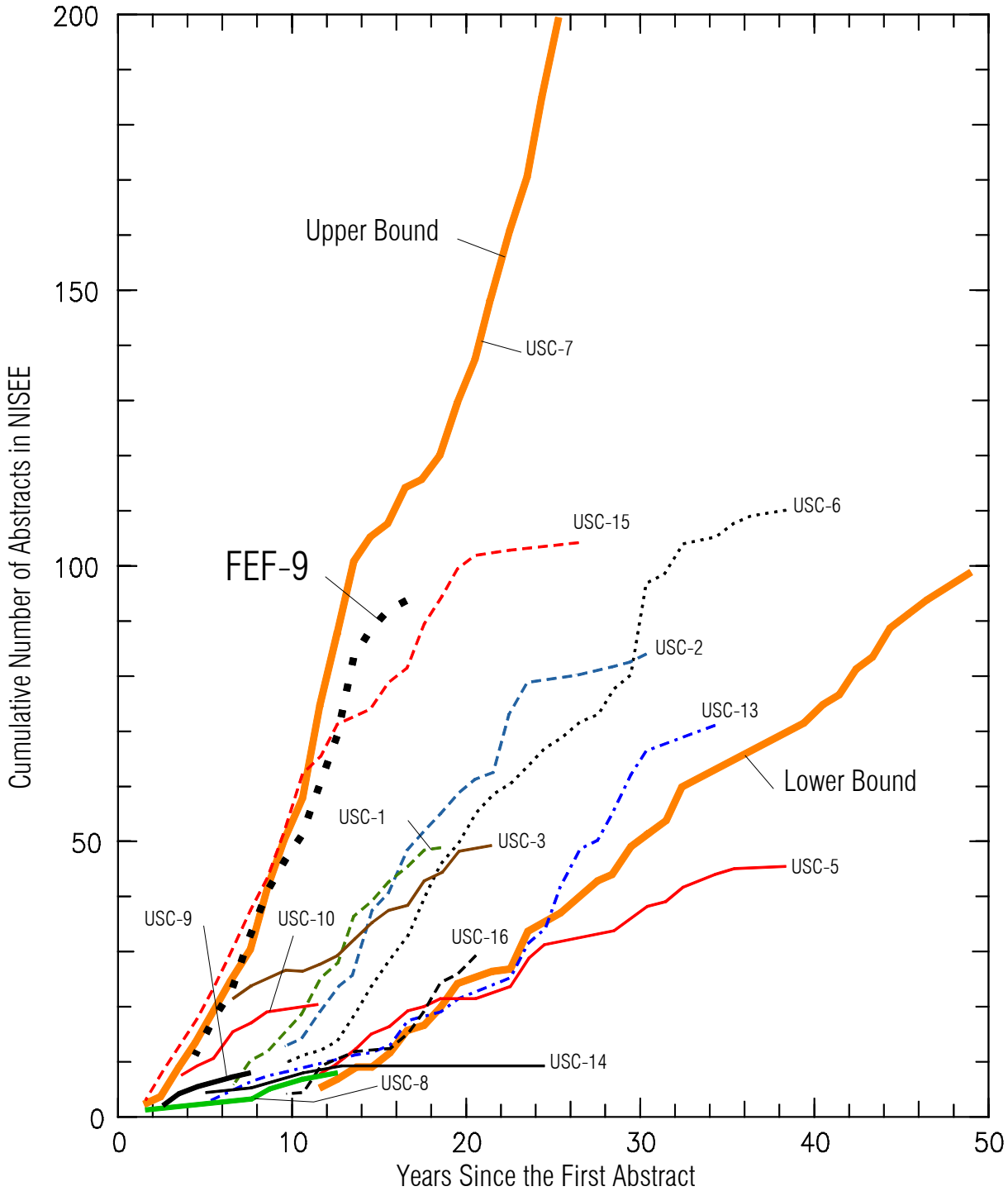

Fig. D.7: Comparison of the cumulative number of abstracts in the NISEE database versus time (since the first citation) for 13 male faculty and one female faculty of the USC Civil Engineering Department.

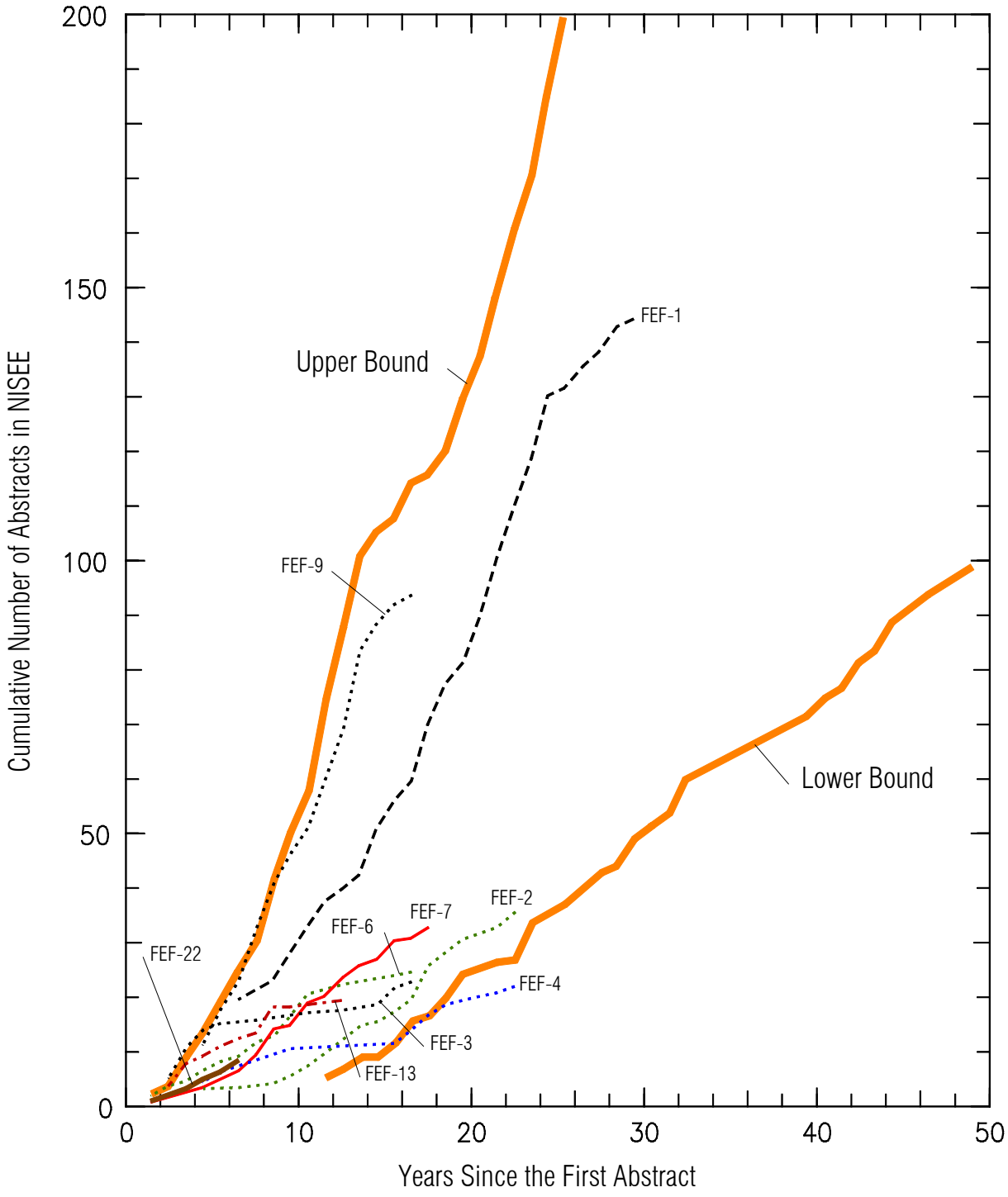

Fig. D.8: Comparison of the cumulative number of abstracts in the NISEE database versus time (in years since the first citation) for nine female faculty in earthquake engineering (see also Table D.3).

USC-1, USC-8, USC-17, USC-18, USC-6, USC-15,etc..), our sample of male faculty included mostly the older, retired (CIT-1, UCB-2, UCB-3) or deceased (Biot, UCB-1, UIU-1) leaders in their fields. In fact, the youngest male faculty members (except for those at USC) in the sample (JH-1, UCB-10, UIU-2, RU-2) are all but one at the full professor rank. In contrast, a large percentage of the female faculty in our sample are recent—hires i.e., at the assistant professor rank. What is important to note about the rates in Fig. D.10 is that the performance of 3 (FEF-1, FEF-9, and FEF-7) of the 17 female faculty considered in Figures D.9 and D.10 (approximately 1 in 5) equals or exceeds many of their male counterparts. If we considered all male academics in the related areas, it is almost certain that the corresponding fraction for them would be far smaller than 1 in 5.

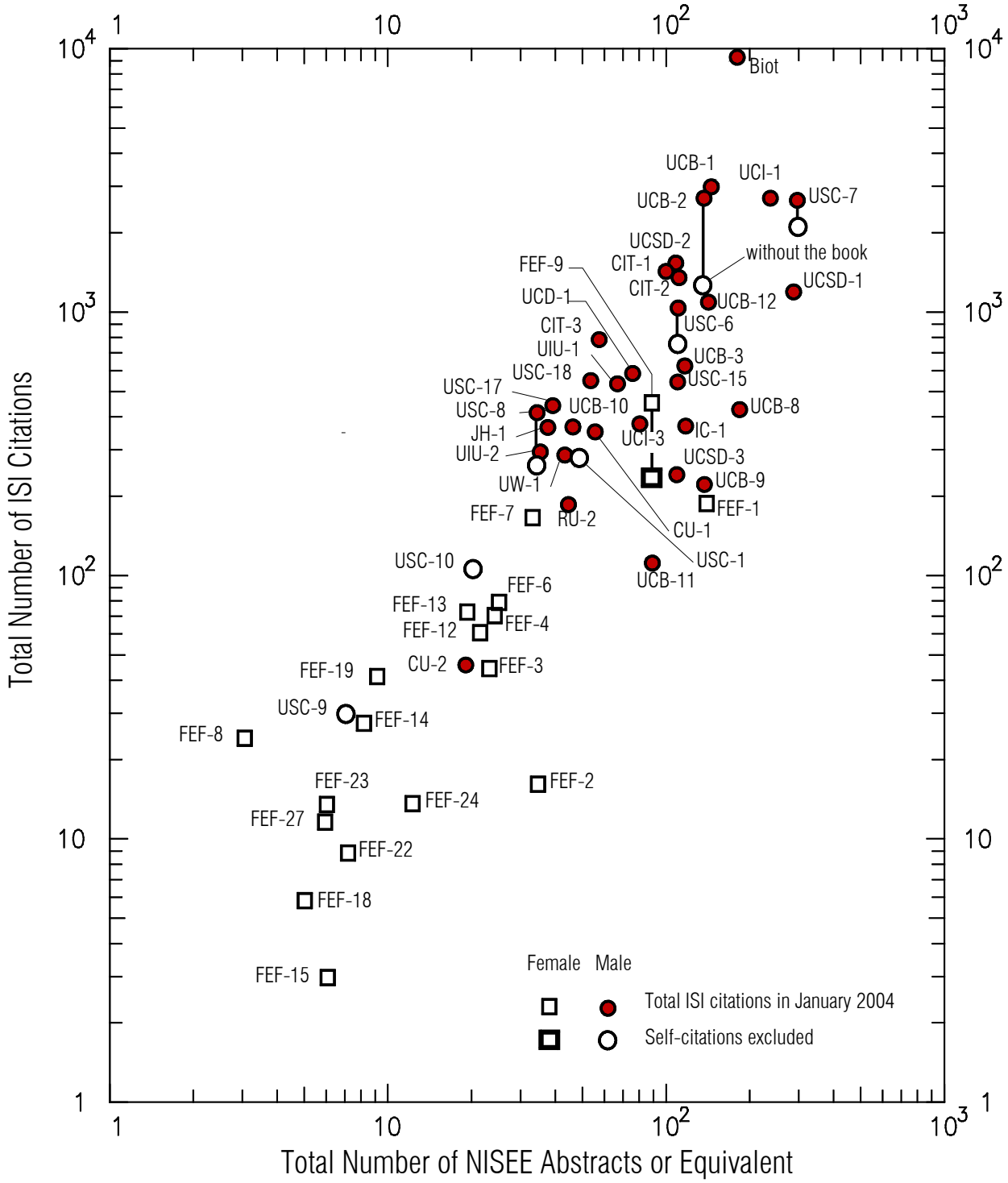

Fig. D.9: Comparison of male and female academics in the fields of mechanics and earthquake engineering via a scatter plot of the total number of citations in the ISI database versus the total number of abstracts in the NISEE database.

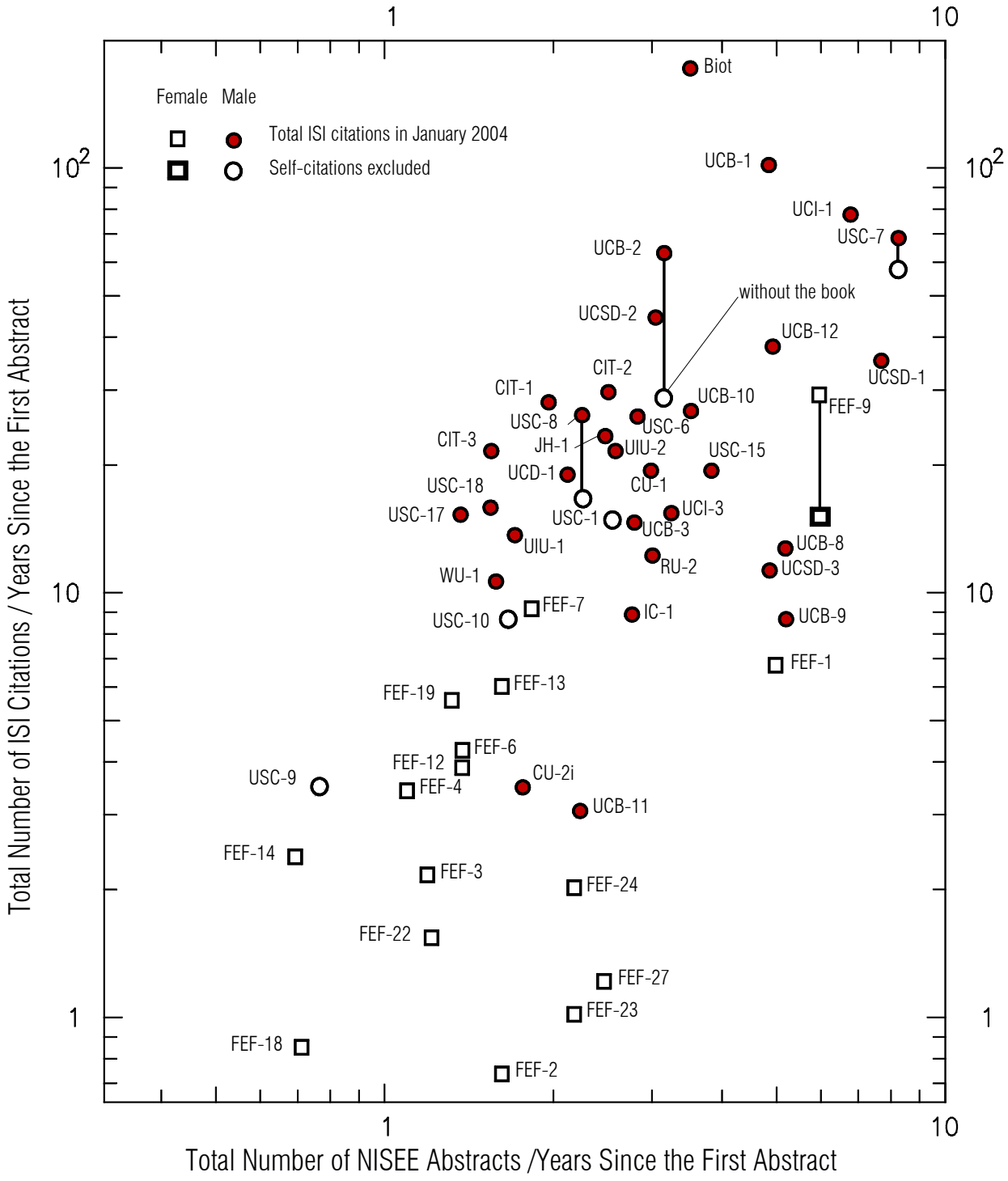

Fig. D.10: Same as Fig. 9, but for the average citation rate per year versus the average number of abstracts in the NISEE database.