THE CIVIL ENGINEERING GRADUATE PROGRAM AT PUC-RIO: A BRAZILIAN EXPERIENCE

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***Abstract**: The Brazilian graduate programs in science and engineering were created in the 60's as a result of a national policy to foster graduate studies [01]. Among them, the graduate program in Civil Engineering at the Pontifical Catholic University of Rio de Janeiro (PUC-Rio), which initiated a master program in Structural Engineering (1965) and Geotechnical Engineering (1967), followed by a doctoral program (1984), in both areas. During the 70's, a period of faculty formation at Ph.D. level was undertaken in some of the most prominent universities of Europe, United States and Canada, effort in great part made possible due to scholarships from the national sponsoring agencies Capes and CNPq. After this phase, the program has rapidly reached its full potential, awarding a total of 436 master degrees and 30 doctoral degrees, until December 1997, to graduate students come from almost all states of Brazil and from many countries of Latin America, such as Paraguay, Argentina, Peru, Colombia, Costa Rica, Ecuador, among others. This diversity in student origin is a quite important asset of the program, an affirmation of its great influence, appeal and leading role in Brazil and Latin America. This paper intends to present the development of the graduate program in Civil Engineering at PUC-Rio in the light of some selected statistical data. The formation of faculty members, the increasing participation of women as graduate students, the evolution of student enrollment and their professional destination, the financial support of federal sponsoring agencies, among other points, are discussed in next sections.*

FACULTY MEMBERS

PUC-Rio is the oldest Brazilian private university, established in 1941. Its importance in the national academic scenario has greatly increased since the 60's when the university committed itself to become the nation's main private research-oriented institution in sciences and engineering. Today, all graduate courses of the university are among the best ranked in Brazil, according to the biennial academic surveys conducted by Capes, a special agency of the Education Ministry, with the graduate program in Civil Engineering deserving the highest scores in all evaluations.

Since its beginning, the graduate program undertook a great task in planning and forming its faculty members and technical academic. This process occurred mainly during the period 1965-1982 when previously selected M. Sc. graduates were invited to work at the department as auxiliary professors for two or three years before going abroad to pursue a Ph.D. degree. During this time, while at the department, the fresh professionals would co-work with more experienced professors in teaching and research appointments to, later on, select a suitable Ph.D. program provided that: first, the chosen program would have to stand a high international reputation and, second, the problem of an endogenous faculty would have to be avoided since even the formation of a group of professionals from the same international institution would be detrimental for an emerging graduate program. Different people, different ideas! Thus, the formation of faculty members followed these general recommendations and its diversity can be illustrated through table 01, where the universities, and respective countries, are listed.

The most favorable consequences of this diversity in the academic staff appears to be the necessary independence to conduct research at M.Sc. and Ph.D. levels as well as the introduction of new graduate courses, some innovative research programs, the establishment of joint researches with international institutions, among other factors.

Table 01 - Faculty members formation.

Number	Country	Universities
4	Canada	U. of Alberta, U. of British Columbia
5	USA	Stanford U., U. of Arizona, Cornel U., U. of Colorado, Rice U.
6	England	Imperial College, Manchester U.
3	Germany	U. of Sttugart, U. of Darmstaad
4	Brazil	PUC-Rio, UFRJ
Total - 22		

EVOLUTION OF ENROLLMENT

The evolution of graduate student enrollment is illustrated in figure 01, from which it can be seen that the master program presented a peak of enrollment during the period 1988-1990, with an average of 90 students per semester. This peak can be attributed to some delay in thesis completion but its main reason was probably due to the high number of new students admitted in that period, when the number of scholarships for graduate studies was greatly increased by the Brazilian government.

In the last years (1991-1997) the average number of enrollments has been quite steady and around to 70 per semester, being the typical duration for an M.Sc. degree between 24 and 30 months. The requirements for the M.Sc. degree are at least 24 semester units of graduate courses, proficiency in the English language, plus a thesis. For living expenses, practically all students receive a financial aid equivalent to $635.00 dollars from the federal sponsoring agencies Capes or CNPq during 24 months.

Upon the introduction of the D.Sc program in 1984, the enrollment in 1985 started with just 3 students. During the next ten years (1985-1995) one can observe from figure 01 the gradual rise in the D.Sc. enrollment, reflecting the interest of many M.Sc. students to continue their graduate studies at the D.Sc. level. Also, it is important to notice that a significant part of this demand for a D.Sc. degree has come from faculty members belonging to other Brazilian universities, fostered by a specific plan coordinated by Capes (called Capes/PICDT), whose main objective is to improve the academic performance of Brazilian universities. In the last years (1995-1997) the number of enrollments has stabilized at an average of 60 D.Sc. students per semester. Presently, the total number of graduate students in the Civil Engineering program has shown an average of 130 per semester.

A more severe delay has been observed for the doctoral completion rate (average time of 60 months) and the Department is now committed to shorten this time with stricter academic rules and a more careful supervision of the graduate students, taking care of the proper time for setting specific stages of the program, such as course completion, qualifying exam, thesis proposal exam, research and, finally, thesis defense. The requirements for the D.Sc. degree include the elaboration of a D.Sc. thesis, proficiency in two modern languages (English mandatory) and 48 semester units of graduate courses, which represents, typically, another 2 semesters of graduate courses beyond the master's degree.

For living expenses, practically all D.Sc. students receive a financial aid equivalent to $930.00 dollars from the federal sponsoring agencies Capes or CNPq during 48 months. Scholarships are also available to some foreign students (from Latin American countries, typically) through a special training program coordinated by Capes and known as PEC/PG. The scholarships awarded to foreign students are equivalent to those conceded to Brazilian students.

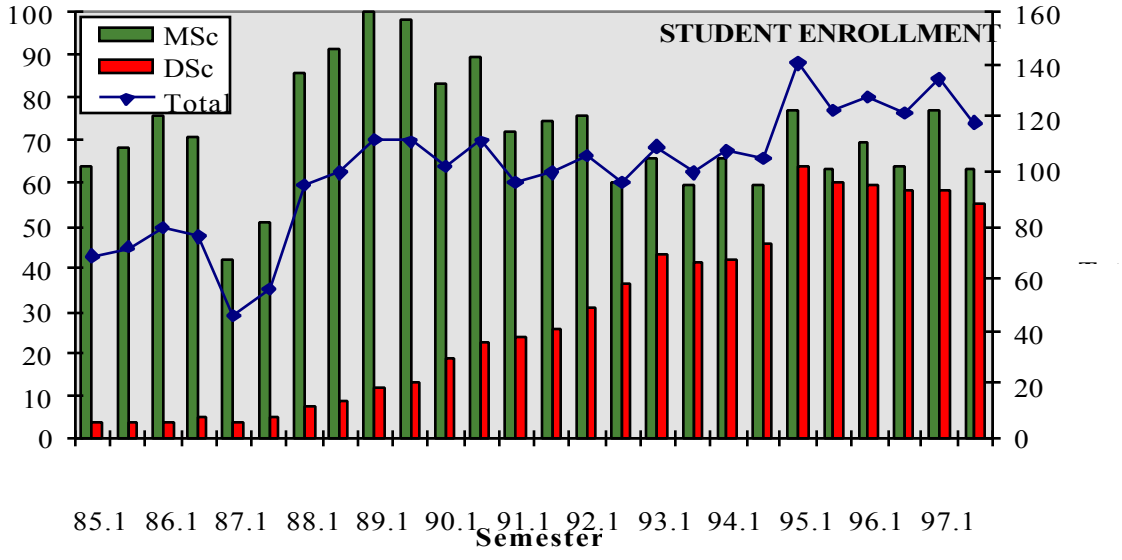

Figure 01 - Student enrollment statistics.

WOMAN PARTICIPATION

Figure 02 illustrates the participation of women in the Civil Engineering graduate programs per decade. This statistics is based on the total sample of master students, i.e. the 436 students that have enrolled and completed their degrees. The statistics relative to the 90's is partial since the data cover only the period 1990-1997.

One can observe the rapid growth in the number of female students from the 60's to the 80's. This increase reflects both the rising interest of women on advanced studies, following the international trend, as well as the great need of highly trained engineers in the process of establishing the Brazilian industrial infrastructure, which has mostly occurred in that period.

It is worthwhile to observe the market trend for setting the level of technical qualification compatible with current job demands. This is a valid observation irrespective of the graduate student gender. In fact, the level of M.Sc. has been seen as an asset for the female applicant to a job position within sophisticated industries and engineering companies.

According to an NSF report [02], women participate in 20% of all U.S. civil engineering graduate students enrolled in the fall term in 1993. The percentage of women in the department of Civil Engineering of PUC-Rio is approximately the same, around 22%.

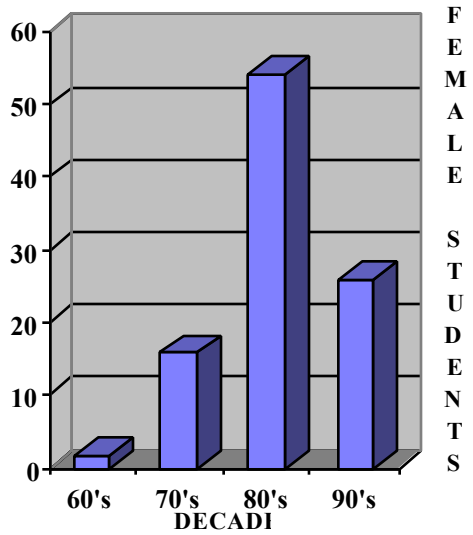

Figure 02 - Participation of women in the graduate program of Civil Engineering.

THESIS COMPLETION

Figure 03 shows the data regarding thesis completion in both programs (M.Sc. and D.Sc. degrees). The master program has increased the average outcome of theses, from 13 per year during the period 1985-1987 to 22 theses per year in the period 1988-1997. The effort undertaken by the department to reduce the time to obtain the master's degree, combined with the fact the D.Sc. program was implemented in the mid 80's, imposing a very new and challenging prospective to the program, have produced their effects in terms of a higher thesis completion rate since 1988. On the other hand, the D.Sc. program has produced an average number of 2 thesis per year, during 1985-1993, to just 5 during the period 1994-1997, despite the relatively large number of students registered (around 60 per semester). Among several possible reasons for these poor results, two facts seem to be predominant: a) the D.Sc. program is undergoing a longer maturation process than the master program to reach its full potential; b) a significant number of D.Sc. students are hired by some universities before thesis completion, increasing the time to candidates obtain their doctoral degrees, since they rapidly get involved with new professional tasks and become quite affected by the distance from the advisor, the lack of equipment and bibliographic materials to conduct research in the other university, the loss of a research-oriented environment that very often decreases the student motivation, etc. Nevertheless, it is still expected that the number of D.Sc. theses per year will grow in the next future due to more restrict policies adopted by the department and the sponsoring agencies.

Another important fact that will influence the graduate program in Civil Engineering, particularly the master program, is a unilaterally decision taken recently by CNPq, dramatically limiting the number of new graduate scholarships to all Brazilian graduate programs. At PUC-Rio, as a consequence of this measure, the availability of scholarships for master's students decreased more than 30% from 1996 to 1998. As an attempt to minimize such effects in the graduate program, the department is now seeking the collaboration of large public and private enterprises, a kind of cooperation not very common in Brazil, but certainly necessary (but not in substitution to governmental funding) from now on.

ORIGIN OF STUDENTS

One of the most remarkable features of the graduate program is the diversity of student origins (table 02 and figure 04). Keeping in mind the national broadness, it is worth to emphasize that approximately 2/3 of the 436 master's degrees were awarded to out-of-state students, including 35 civil engineers from Latin American countries. This overall scene confirms the undeniable national character of the graduate program and its well known reputation of academic excellence in Brazil and Latin America.

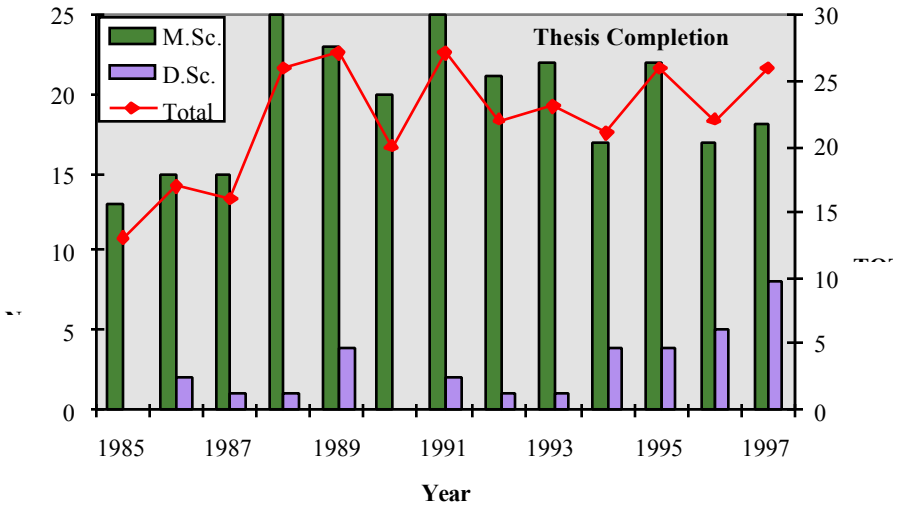

Figure 03 - Thesis completion statistics

Table 02 – Regional distribution of master's degrees from 1965 to 1967.

Region	Color (Fig 4)	Students	%
North	dark green	26	6.0
Northeast	red	112	25.7
West	light green	28	6.4
East (Rio de Janeiro) East (other states)	blue blue	151 48	34.6 11.0
South	orange	36	8.3
Latin America	not shown	35	8.0
Total		436	100.0

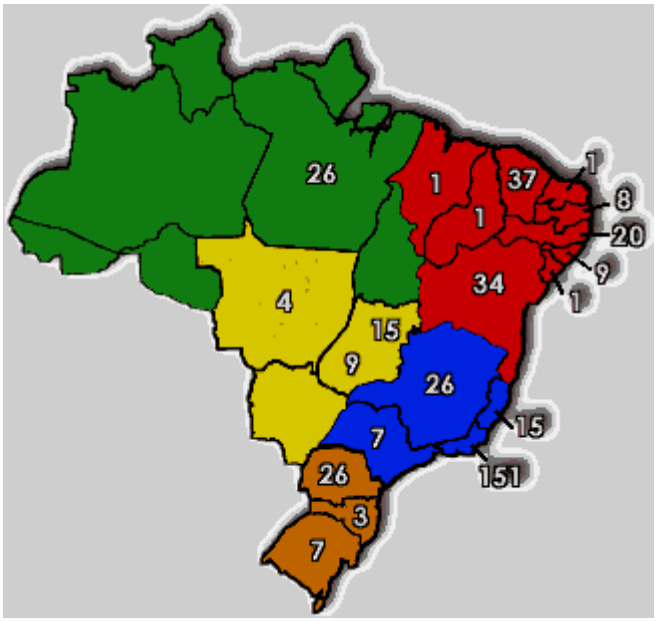

Figure 04 – State distribution of student origins.

DESTINATION OF STUDENTS

A recent survey about the professional destination of more than 400 alumni who completed the graduate program in Civil Engineering at PUC-Rio in the last thirty years, has revealed that about 10% of them are still pursuing a D.Sc. degree either in Brazil or abroad, 30% work as engineers in their areas of specialization and the great majority, approximately 60% of the alumni, are engaged in teaching and research activities in more than 30 Brazilian universities, among then the main public institutions such as the Federal University of Rio de Janeiro, the Federal University of Minas Gerais, the Federal University of Rio Grande do Sul, University of São Paulo, the Federal University of Paraná, the Federal University of Bahia, etc.

According to Capes, Brazil has now 33 graduate programs in Civil Engineering (25 with Master's degrees and 8 with Doctoral degrees), many of them created by alumni from PUC-Rio in the last decade, such as the graduate programs at the Northern State University of Rio de Janeiro and the Federal University of Ouro Preto, for instance, among others. If this fact well illustrates the great success of PUC-Rio in its mission of forming highly qualified human resources, on the other hand it also indicates that the graduate program must increase efforts in the next years to remain competitive and to be firmly established as a Latin American center of excellence in Civil Engineering.

CONCLUSION

This paper has intended to present the evolution of the graduate program in Civil Engineering at PUC-Rio, from the difficult beginning in 1965 to present days. In all these years, many good things happened and, in this conclusion, it is rewarding to mention some, and to be grateful, such as the important encouragement received at given time from the University of Alberta, Canada, and, mainly, the constant and invaluable financial support from the federal agencies Capes and CNPq.

REFERENCES

[01] Schwartzman, S., "The Science Tree", *Science Today*, V.2, N.15, 1984, pp.70-84 *(in Portuguese)*.

[02] NSF, "Women, Minorities and Persons with Disabilities in Science and Engineering*", Report National Science Foundation*, 1996, p.203.