Master's degree on Soil Mechanics at CEDEX: an example of collaboration among government, academia and industry

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ABSTRACT: The Spanish research centre CEDEX (*Centro de Estudios y Experimentación de Obras Públicas*) has been organising an international postgraduate Master on Geotechnics since early 1980s, evolving from a 3-month course, forged as a tool of international cooperation with Latin American developing countries, into a reputed postgraduate master (now with ~1000 alumni). The following features stand out, among other: an enduring onsite course in Spanish, varied affiliations (industry, administration and academia) and engagement of its lecturers and the contribution of host universities (U.P.M. and UNED), technical societies and alumni (nearly 25 % of the lecturers are alumni). The paper describes: its origin, the various policies the Master has followed; the syllabus evolution and the assignments; and the assessment of the performance of the students. A retrospective review is included as well. To the authors' experience, an onsite intense course with: (a) a sound syllabus and varied lecturers; (b) a proper environment (students a bit under pressure, yet at ease); and (c) weekly assignments that prompts cooperation, is a successful combination.

Keywords: Master's degree, soil mechanics, geotechnical engineering, Spanish language

1 Introduction

CEDEX is a unique public research centre attached to the two Spanish ministers responsible for infrastructures, transportation and environment. CEDEX has been organising uninterruptedly a course taught in Spanish since early 1980s that has evolved over the years into a postgraduate master on Geotechnics, that annually selects between 25 to 30 international students (to date, ~1000 alumni), with recognition in the Latin American countries. The objective of this paper is to describe, discuss and gain insight into: the endurance of the master over its evolution; survival after the cut-out of grants and the economic downturn, severely affecting construction in Spain; commitment of lecturers from 3 areas of affiliation (industry, administration and academia); engagement of the Spanish universities; and development of alumni networks that enhance the access to an international labour market and callings of scholarships. The current structure of the master, the driving force that caused the master to come into being, its syllabus, the coursework and the class material are described and examined as well. Besides, educational choices in Spain with respect to the economic context over the past four decades will be briefly discussed. Finally, some retrospective thoughts are shared with the reader.

2 Current structure and features of the Master's degree

2.1 Objectives

The main objective of the master is not to offer a regular university's degree, but rather to provide an as much as possible comprehensive professional education in the field of geotechnics, from theory to practice, in order to advantageously prepare the students to enter the labour market. A few, however, take the chance of joining a research project. Surely, decades ago, when access to information was

scarce and the vast majority of student came from Latin America, the purpose was as well to provide with as much information as possible to the students, some of them having vocation for academia.

The Spanish students, very few until mid-90s, began to be gradually interested in the course. In fact, in the last 10 editions Spanish students have represented on average 55% of the class. Among all the applicants, a maximum of 30 students are selected under academic and professional criteria, and to a lesser extent, of geographical diversity. Spanish language skills are required to attend the course.

2.2 The organizing institutions

2.2.1 CEDEX (*Centro de Estudios y Experimentación de Obras Públicas*)

CEDEX (Centre of Studies and Experimentation for Public Works) is a government-owned institute attached to the Ministry of Development (*Ministerio de Fomento*) reporting to the Secretary of State for Infrastructure, Transport and Housing, and with functional service to the mentioned Ministry and the one for Ecological Transition (*Ministerio para la Transición Ecológica*; formerly, Ministry for Environment). When in 1957 the *Escuela de Ingenieros de Caminos, Canales y Puertos of Madrid* (that dates back as early as to 1802), then the only school of civil engineers in Spain, was transferred from the Ministry of Development to the Ministry of Education to become part of the new *Universidad Politécnica de Madrid* (U.P.M.), the School's laboratories, distributed in different nearby buildings, were so well equipped that the Ministry of Development managed to keep them on the grounds of strategy, technical and research assistance. This set of laboratories was the origin of CEDEX (ports, hydraulics, geotechnics, transportation, structures and materials, etc.). Maybe because of that, the institution has always kept certain inclination for education and strong bonds to that School. In fact, a few outstanding engineers used to serve then both as heads of CEDEX Laboratories and as professors at the School.

CEDEX offers unique testing facilities, provides high-level consultancy, contributes to standardization, does applied research and technological development and, ultimately, promotes conveyance to industry. In fulfillment of its commitments, CEDEX uses resources for discussion, training and educational actions, which have gained national recognition over the years, becoming a meeting point and forum on civil and environmental engineering among contractors, practitioners and scholars. Furthermore, the secretariats of a number of technical societies are based in CEDEX (regarding geotechnics, three National Societies: for Rock Mechanics, for Soil Mechanics and for Geosynthetics).

The Geotechnics Laboratory (*Laboratorio de Geotecnia*) has been the venue of the master for decades. This Laboratory is in charge of issues dealing with foundations, earthworks, soil and rock mechanics, and in general, the civil engineering activities linked to the ground, mainly at the request of the National Port Authority (*Puertos del Estado*), the administrations for railways, roads and water resources - *Administrador de Infraestructuras Ferroviarias*, (ADIF) & *Dirección General de Carreteras*, *Dirección General del Costas* & *Dirección General del Agua*. Nonetheless, the Geotechnics Laboratory stands out in research, sometimes in collaboration with other institutions. Proof of this is the considerable number of PhD theses (more than 15 in recent years) that have been carried out in the Laboratory, alone or in collaboration with universities.

2.2.2 UNED (*Universidad Nacional Española a Distancia*)

UNED (National Distance Education University), founded in 1972, is the only off-campus public university in Spain; besides, it is one of the very few universities that, unlike the vast majority in Spain (transferred to regional governments), is attached to a Ministry (Science, Innovation and Universities). UNED (https://www.uned.es/universidad/inicio.html) is the host University of the Master since 2012.

UNED has the largest student population (>260 000) in Spain and is one of the largest universities in Europe. It offers 27 bachelor´s degrees, 76 official university master's degrees and 19 doctoral programs adapted to the European Higher Education Area (EHEA). Even though its headquarters are based in Madrid, it is present nationwide in the form of 61 associated centres (campuses) and more than 100 extensions and classrooms, where tutoring takes place and also serve as venues for the onsite exams. It also has offices abroad, in 13 countries: 6 in Europe; 6 in America; and one in Africa.

2.3 Other supporting agencies or organizations

AETESS (*Asociación Española de Empresas de la Tecnología del Suelo y del Subsuelo*) (https://aetess.com/) was established in 1977 with the aim of supporting an emerging market for the largest national contractors dealing with ground engineering (special foundations, soil improvement and treatment), embracing commitment to quality, safety and professionalism). Thus, AETESS shares its technical activities with public institutions, associations and standardization entities. Accordingly, AETESS is the Spanish member of the European Federation of Foundation Contractors (EFFC), which represents 370 foundation contractors of 16 European national federations.

With regard to the Master, AETESS has been strongly engaged for decades, both on hosting on site visits and conferences. Lectures on ground improvement techniques are addressed by its highly experienced engineers. In fact, the master itself is its basic source of recruiting qualified personnel. No wonder that many of the technical managers of its member companies are alumni.

AECID (Spanish Agency of International Cooperation for developing), attached to the Ministry of Foreign Affairs, was founded in 1988 as an entity for management of policies in the scope of international cooperation for development and combating poverty. Even though AECID have not collaborated actively since 2012, it is fair to acknowledge its support over the past decades, because AECID used to grant every edition between 10 to 20 outstanding students from abroad, covering the basic expenses of the Master (accommodation, cost of living and academic fees). Hence, it was a crucial agent in promoting the master in Latin America for decades.

2.4 The syllabus and lecturers

2.4.1 Syllabus

The course is arranged into a compulsory attendance period, being held from February to June, plus a 3-month period, from July to October, during which each student has to write, under the tutoring of a lecturer, a dissertation to be presented before a board of examiners by October. The classroom period is scheduled daily from 9:00 to 13:30 on weekdays. An ordinary daily timetable would consist of: a first lecture (2h, including a short break), a 30-min break and a second lecture (same format). Besides, afternoon lectures (15:00 to 17:00) are scheduled from 2 to 3 days per week approximately.

The classroom period is divided into three units, each subdivided into modules (each is one-week long). The syllabus is supplemented with sessions on advanced geotechnics. The content of the modules per unit and the sessions of AG are shown in Table 1.

Lessons on principles of soil and rock mechanics are addressed as if the students had not previous knowledge; yet, concepts are conveyed in much deeper detail than a regular university course. Lectures on geothermal issues, off-shore foundations, reservoir geomechanics and Eurocode 7 were included 5 years ago, whereas some lessons on structural design of foundations have been reduced.

Table 1. *Content of the modules, arranged into units and sessions on advanced geotechnics*

First Unit	***Second Unit***	***Third Unit***
Principles of soil mechanics I	Shallow foundations	Earthworks and fills
Principles of soil mechanics II	Deep foundations	Tunnels
Principles of soil mechanics III	Slope stability	Soil improvement
Field investigation	Earth retaining walls	Dam & tailing geotechnics
Principles of rock mechanics		Numerical methods and modeling
(+ 3 lab sessions)		Environm./Energy Geomechanics
		Soil dynamics (+ lab session)
Sessions of Advanced Geotechnics: (*nº of lectures in brackets*): clay mineralogy (1); foundations of offshore structures (2); Geotechnical reliability and risk assessment (1); Constitutive models (2); Critical State Theory (4); Eurocode 7 (1); Limit State: upper and lower bound theorems (2); unsaturated soil mechanics (4); reservoir geomechanics (2)		

2.4.2 Lecturers

Nearly 25 % of the lectures are alumni. As shown in Table 2, the affiliations of the contributing lecturers is varied. Lessons dealing with principles of soil and rock mechanics are taught mainly by the Geotechnics Laboratory Staff (~45 % of all the lectures), and to a lesser extent (~15%), by faculty members from the School of Civil Engineering (U.P.M). Some of the topics concerning singular machinery (hydrofraise, sheet diaphragm wall technologies, grouting, TBM, singular borings, etc...) are commonly addressed by experts of AETESS, who apply the theory to their everyday professional work. Many of them volunteer to be a tutor or a member of the board of examiners of the theses. Students have then a unique opportunity to show their capabilities to enter the labor market.

Table 2 *Affiliations of the lecturers (~75 in total) that contribute in the master (last 5 years)*

Administration & government owned institutes (60 %)
Geotechnics lab. (core lecturers, 45 %) + Structures & Materials lab. (CEDEX)
Instituto Geológico y Minero de España (IGME)… ≈*National Geological Survey*
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas (CIEMAT) (≈CEDEX, but attached to the Ministry of Science, Innovation and Universities)
Centro Internacional de Métodos Numéricos en la Ingeniería (CIMNE)
Ministerio de Fomento, Dirección General de Carreteras (roads)
Ministerio de Medio Ambiente (Dirección General del Agua) ≈ water resources
Confederación Hidrográfica del Ebro, ≈River Ebro Authority
Bundesanstalt für Materialforschung und -prufüng (BAM) ≈German counterpart of CEDEX
Contractors and engineering offices, 18%
From members of AETESS: ~8%
Companies: REPSOL, Ferrovial, Acciona, Arup, Euroestudios, Geobrugg ~8%
Offices: Uriel & Asociados, Túneles y Asistencia Técnica (Tunelestat) 2%
Academia (in brackets nº of lecturers) ~22% *(the Spanish universities and faculties below are public)*
Civil Engng. Schools: Madrid (8); Santander (2); Barcelona (3); La Coruña (1); Granada (2); Valencia (1) *Other:* Geology Faculties: Madrid (1); Mining Schools: Madrid (1); Vigo (1) *Engng. Schools from abroad:* University College of London (1); Texas A&M, Univ. College (1)
Approximately 75 lecturers in total; nearly 25 % of the lectures are outstanding alumni.

Fortunately, research groups from nationwide universities take over lessons in their own field of expertise (i.e. CIEMAT and U.P.C. on unsaturated soils; U.P.M. and CEDEX on rock mechanics; and CEDEX and the group "m2i" in U.P.M. and lecturers from U.C.-Santander, on numerical modeling).

Despite the extra effort on organization, bringing together lecturers from different affiliations and areas is high rewarding for the student; such variety seems hard to attain in a master's degree offered by universities. Another asset is the flexibility to change or add lecturers over the years, and, for instance, to introduce new technologies in the industry and, ultimately, keeping the syllabus updated.

2.5 Coursework and criteria of evaluation

2.5.1 Coursework, geotechnical software and continual assessing

Students are handed out weekly individual assignments (problem solving), generally, one per module, to make the continual assessment easier. With the aim of getting the most of theoretical lessons, worked examples are explained in detail on the blackboard within the following days. Assignments, though individual, prompt fruitful discussion among classmates in their struggle to work out the result.

In addition, students are presented with a few practical assignments to work in groups to promote collaborative skills. The following assignments of this kind are worth mentioning: (a) a field day trip to a rocky outcrop where a detailed geomechanical survey has to be carried out with field tools, plus a rewarding cultural visit in the afternoon (to the Escorial Monastery); (b) a drill on drawing up an economic-technical report for a pretend tender (the teacher) offering an underground geotechnical project (explained in the classroom with guidelines on how to prepare it); the students (pretend bidders) have to make a short presentation as well, facing questions from the "tender"; (c) case histories (one shared by 5-6 students) addressed by CEDEX in the past; the group is requested to come up with their own geotechnical solution or design.

Particularly, the assignment relating to the module on numerical modeling includes classroom tutorials of Midas GTS NX and several exercises to be solved in groups. The choice of GTS NX resulted from the chance of having at CEDEX's disposal a free fully unrestricted license per student throughout their enrolment; in the past, the student version of PLAXIS was used instead to solve simple cases. In any case, PLAXIS, DIPS, SWEDGE and GEOSLOPE are briefly introduced to students. Any developer of geotechnical software is welcomed to contact the Master's academic board for educational purposes.

There is certainly an open debate (to be addressed elsewhere) about the point of making software available to students when they still can hardly solve simple problems by analytical methods.

The coursework described above comprises a continual evaluation that represents 20 % of the global assessment of the student's performance during the attendance period, whereas the average score of the three exams (at the end of each unit) is 80 %. Nevertheless, the weighed marks resulting from these two is 70% of the total, being the Master's thesis (written document + presentation) 30%.

2.5.2 Class materials and reference books

Upon enrolment, students receive the course e-documents (basically, the lecturers' slides from the previous edition, in pdf format, in Spanish as a rule), a series of relevant papers, an access card to CEDEX facilities and 3 easy-to-read text books (in Spanish), useful as a basic supplement for the 1st unit. The 4-volume seminal treatise "*Geotecnia y Cimientos*" (coordinated by Prof. Jiménez Salas, see Section 3.1) used to be the reference book until a decade ago. Many Latin American alumni still evoke the anecdote on departure at the airport about the baggage overcharge due to overweight of this 7,3-kg treatise. Nowadays, a source of knowledge so heavy as compared to a tablet is unfairly unwelcomed. Nonetheless, several copies of this valuable treatise are available in the classroom.

Apart from well-known technical books written in English, technical writings in Spanish are strongly promoted from the academic board, as a means of counterbalance the unnecessary invasion of anglicisms and of joining forces for strengthen the terminology among the Spanish-spoken community. Other sources at the disposal of the students in the classroom are specific courses or conferences held in CEDEX (on paperback). Digital sources in Spanish can be found at: *Revista de Obras Públicas* (http://ropdigital.ciccp.es/); journals of the Spanish (https://semsig.org/boletines-de-la-semsig/) and Portuguese (https://semsig.org/revista-geotecnia-listado/) Societies of Soil Mechanics, as well as CEDEX-AETESS conferences and sessions (https://aetess.com/tienda/) and *Revista Ingeniería Civil*, edited by CEDEX, (http://www.cedex.es/CEDEX/LANG_CASTELLANO/DOCU/PUBLICACIONES/RINGCIVIL/). This journal devoted in 2017 a special issue to the Master, including as papers summaries of the most outstanding master's thesis of that year. The academic board, in fulfilment of the Master's ethos, welcome other sources in Spanish coming from Latin America. Finally, students from abroad have the occasion of becoming familiar with the Spanish technical guides, standards and, in the recent years, with Eurocode 7.

2.6 Facilities and cost

The Geotechnics Laboratory is located in an enclosure adjoining the South limit of the Retiro Park, the green area of the city centre. Sometimes student get together there for a picnic or a midday break. CEDEX is within easy reach of all the main cultural sites and means of transport. The building is fully equipped, with a canteen, WIFI access and a geotechnical library. Students have the chance of visiting the different testing rooms and see some field exploration equipment of the Laboratory. The cost of the master is 6000 euros, which covers tuition fees, course documents, academic trips, schooling, library services, reference books and attendance to conferences. Students just need a budget for the cost of living and accommodation. It is compulsory for students to have a student visa.

3 A long-lasting master on geotechnics at CEDEX

3.1 How it came into being; *initial conditions*

The origin of the master's degree must be sought in 1965 in the Laboratory of Transport and Soil Mechanics of CEDEX (currently, the Geotechnics Laboratory), with the so called “Specialization Course in Transport and Soil Mechanics for Latin American Engineers”, carried out with the collaboration of the Institute of Spanish Culture and the School of Civil Engineers (*Escuela de Ingenieros de Caminos, Canales y Puertos*) of the Universidad Politécnica de Madrid (UPM), in Madrid, still the only Civil Engineering School in Spain.

In the early 1980s, Professor José Antonio Jiménez Salas, the genuine pioneer of Geotechnical Engineering in Spain, conceived a course exclusively on geotechnics for Latin American postgraduates at the School of Civil Engineers of Madrid (Fig. 1), with the aim of promoting technical development abroad. At that time he combined his teaching duties as professor of Geotechnics and Foundations in this School with the post of head of the Geotechnics Laboratory at CEDEX.

On reading the biographical notes of Prof. Jiménez Salas in the tribute book by his epigones (SEMSIG, 2000), the special issue of the *Revista de Obras Públicas*, as well as in the tribute held in the *Real Academia de Ciencias* on occasion of his centenary (http://www.rac.es/4/4_4_1.php?id=109), his devotion for education was evident. His international prestige and extraordinary teaching skills and the highly qualified group of fellow researchers who assisted him, from the School and the Geotechnics Laboratory of CEDEX, led to the dissemination of the course in the countries with linguistic bonds.

Figure 1. Students and coordinators of one of the first International Courses on Soil Mechanics and Foundation Engineering in the early 1980s right in front of the School of Civil Engineers of Madrid.

3.2 From the School of Civil Engineering to CEDEX; *primary consolidation*

After its germinal stage at the School, the VI International Course on Soil Mechanics and Foundation Engineering (1988) was transferred to the Geotechnics Laboratory of CEDEX; Then, say, its “primary consolidation” started as a course under the direction of Prof. Carlos Oteo, at that time Director as well of the Geotechnics Laboratory. Prof. Jiménez Salas remained engaged to the course over the following editions and taught until mid-90's. Figure 2 shows a welcoming session in CEDEX (c. 1988).

3.3 Becoming a master and joining a host university; *secondary consolidation*

In 1996 Dr. Cuéllar was appointed Director of the Laboratory and the course kept evolving, extending its content (critical state, worked examples, limit bound theorems, software practice, etc…). Since 2000, on the occasion of another extension of the teaching burden (from 3,5 to a 5-month length), the course obtained the status of master's degree. During those years the master started to steadily draw Spanish graduates' attention, in a context of prosperity and growth of the construction activity, and therefore, of no distress of graduates for getting a job at any cost.

Figure 2. *Welcoming session (c. 1988): left to right, Mr. Marcelo Rodríguez (CETA); Prof. Jiménez Salas; Ms. Isabel Vilches (CETA); Prof. A. Serrano (head of the CETA); Prof. Carlos Oteo (Director of the Geotechnics Lab).*

With the advent of the Bologna process, CEDEX joined forces again in 2009 with the Polytechnic University of Madrid (U.P.M.) to organize the course, evolving into a postgraduate Master's degree, being compulsory since then to defend a master's thesis. According to the European Credit Transfer and Accumulation System (ECTS) the Master reached an equivalence of 60 credits. In the 2012 edition the master shifted to UNED as a host university, maintaining all its standards and structure.

UNED, being a state (non-regional) university, attached to the Education Ministry, grants even more freedom to the academic board for choosing the most suitable lecturers, whatever their affiliations. Table 3 summarizes the key features of the evolution of the master.

4 Discussion; a retrospective review

4.1 On the heterogeneity of the students

Another feature of the Master is the heterogeneity of the students, which is manifold: the variety of degrees of the applicants (the course is aimed at civil engineers, geological engineers, mining engineers, geologists, geophysicist and related professions), hence the difficulty for the selection committee when comparing CVs; the ample range of ages, and in turn, their expectations (from recent young graduates, enthusiasts for geotechnics and undefined expectations, to senior professionals seeking, perhaps, a recycling course due to uncertain prospects); their uneven background on Maths and Physics. Pondering this factor is essential so as to guide lecturers on how to convey the concepts to the class. Thus, after the welcoming session, every edition students are requested to fill in a questionnaire with elementary questions (physical units, forces and bending moments of a cantilever beam, the surface of a sphere, the true meaning of gradient, etc...). In doing so, those in need of going over basic concepts come to terms with their weakness for completing the master successfully.

4.2 The human factor: classroom learning, technical visits/trips, group assignments

Several field trips are organized, including a two-day ice-breaking technical visit during February and a 5-day trip, typically in May. During this trip relevant geotechnical ongoing work in construction sites in a region of Spain are visited, guided by lecturers involved in them. The aim of these field trips is dual: to offer true contact with geotechnical activity and techniques on site; and to foster fraternization among not only class-mates, but as well with professionals and alumni working on site and lecturers. Besides, a casual professional workshop in the classroom is programmed by early June, with panelists from AETESS and national societies and presentations of outstanding alumni (about recent geotechnical projects or even their own experience). In the long run, all this interaction forges a network and bonds really fruitful in their professional career.

Table 3 *Summary of the evolution of the Master on Soil Mechanics and Geotechnical Engineering*

	Course U.P.M.	***Course at CEDEX***		***Master***	**Master 60 ECTS**		
Years	1982-1987	1988-1997	1998-1999	2000-2008	2009-2011	2012-2016	2017-2019
Director	J.A. Jiménez Salas	C. Oteo (until 1997)	V. Cuéllar	V. Cuéllar (until 2006) F. Pardo de Santayana	F. Pardo de Santayana	F. Pardo de Santayana	F. Pardo de Santayana
Coordinator	C. Oteo	F. Pardo de Santayana (until 1992) J.C. de Cea	J. Sáez	J. Sáez (until 2006) J.Estaire A. Perucho	J. Estaire A. Perucho	E. Asanza J. González-Gallego	E. Asanza J. A. Díez C. Higuera
Venue	School of Civil Engng. (U.P.M)	Lab. Geotecnia CEDEX		Lab. Geotecnia CEDEX	Lab. Geotecnia CEDEX	Lab. Geotecnia CEDEX	Lab. Geotecnia CEDEX
Degree title	Course (3 months)	Course (3,5 months)		Master (5 months)	Master 60 ECTS + Master thesis	Master 60 ECTS + Master thesis	Master 60 ECTS + Master thesis
Role of univesity	course U.P.M.	Collaboration U.P.M.		Collaboration U.P.M.	Master U.P.M.	Master UNED	Master UNED
Remarks	All students from Latin America	Lab sessions still at the School of Civil Eng. Very few Spanish students		Growing interest among Spanish engineers	~ 50 / 50 geographical origin (from abroad /Spanish)		

Figure 3 shows a flyer of the upcoming edition (38th) and nationalities of students since 1988. Despite the cultural bonds among Ibero-American countries, sharp differences of idiosyncrasy, social background and barriers are found among the students.

Figure 3. *Flyer of the 2020 edition (38th), and of students' nationalities since 1988.*

Unlike in soil mechanics, in this respect, heterogeneity among peers is an unpaired source of learning that is taken in naturally by socializing over more than 5 months. Thus, Figure 4 evokes the aphorism "*a picture is worth a thousand words*". It is worth mentioning the conference promoted by Prof. Marcelo Sánchez (Texas A&M University, Prof. at the Civil and Environmental Engineering School) and his classmates (his life-long friends) of the 1994 edition, happily sponsored by CEDEX in 2017. That conference served as well as a reunion in the venue where they first met, that determined the course of their lives. The current and two former directors of the master and several alumni were speakers at that successful conference (http://www.cedex.es/NR/rdonlyres/18E1E2CF-7366-4CE3-86BF-16E3268DDC1E/143440/FolletoSeminarioMaster94_v2.pdf).

Figure 4. "A picture is worth a thounsand words"; A) Bridge "Constitución" (Cádiz); B) in class; C) near the El Escorial Monastery, after the geomechanical survey; D) visiting a tunnel for the high-speed line in Galicia.

4.3 Economical context in Spain over the years and educational choices

Figure 5 shows a timeline since 1965 with relevant milestones. The red coloured background graph shows the annual consumption of cement (10^6 tonnes) in Spain, sometimes used as reference of the activity in the construction industry. The sharp growth and the subsequent drop identify the economic downturn that affected worldwide and really badly this industry in Spain. The names of the most renowned schools of civil engineering are labelled above the graph of cement consumption, approximately on the year of the 1st graduation. The lower part of the figure shows the educational choices other than a regular degree at university. Two events have disrupted the traditional balance of university choices: the advent of degrees on Engineering Geology in the late 90'); and the uncontrolled thriving of degrees in civil engineering as a result of the Bologna process.

A sound postgraduate course is a fairly good ally for those determined to work in the core of civil engineering. The master has endured throughout all the past difficulties and is still coping with them. Yet, in a global world, when any Ibero-American geotechnical company tries to open business abroad, alumni are good choices.

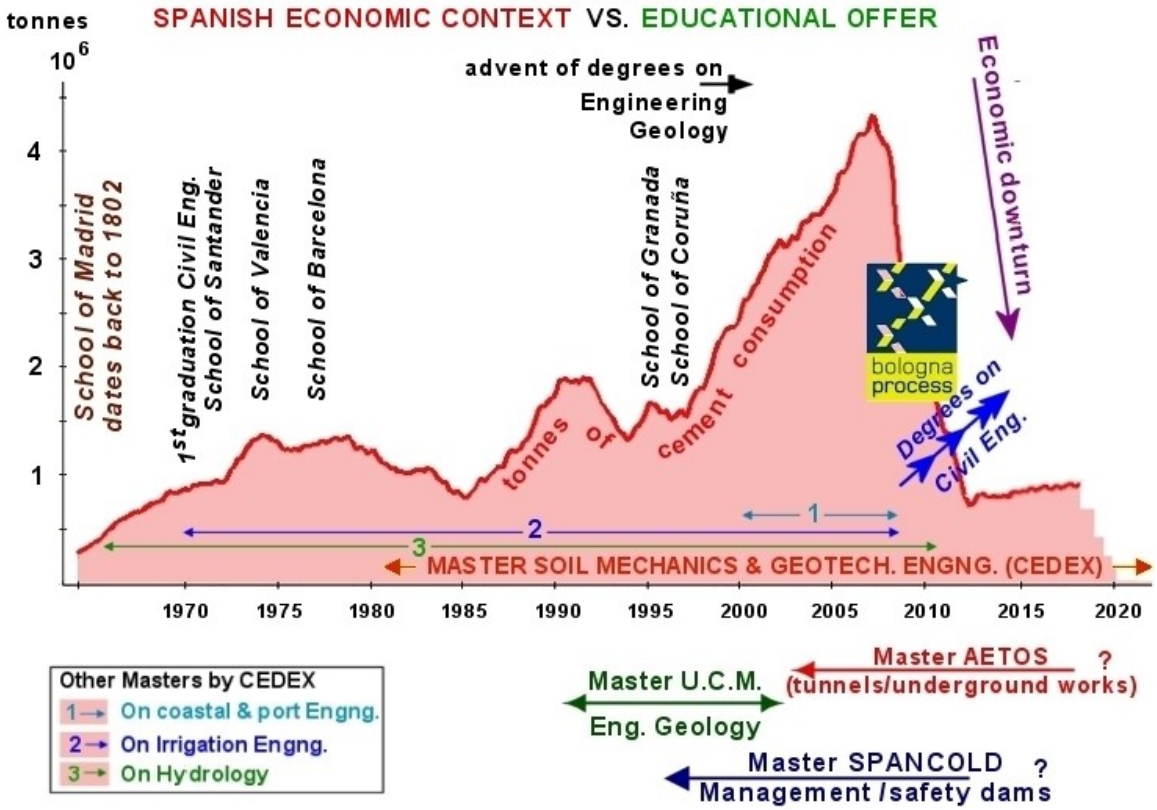

Figure 5. A snapshot of the Spanish education offerings over the last decades in relation to the economic context.

5 Conclusion

Despite the costly resources required (hence, the advantageous position of public service), in the authors' experience, onsite learning with sound syllabus with varied lecturers, an international environment where the students are at ease but a bit under pressure by weekly assignments, leads to success. Furthermore, heterogeneity among peers (ages, prospects, background, countries, degrees, etc…) , in a global context, is an unpaired source of learning that is taken in naturally by sharing more than 5 months of hard work. The variety of affiliations of the lecturers is one of the key factors for the success of the master, as it provides the student with both theoretical background and applicability to the everyday professional work.

Finally, as technical writings in Spanish are strongly promoted from the academic board as a means of counterbalance the unnecessary invasion of anglicisms, the authors perceive that the terminology among the Spanish-spoken community have been strengthen.

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