



# **CERIS - CIVIL ENGINEERING RESEARCH AND INNOVATION FOR SUSTAINABILITY**

## **Scientific Report 2017**

## **Programmed Research for 2018**

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## SUMMARY

CERIS - Civil Engineering Research and Innovation for Sustainability - is a research unit that operates in the Built and Natural Environment sector. In 2017, CERIS had 115 PhD members, 104 PhD collaborators and 244 PhD students enrolled at IST, and covered the following domains, with different levels of depth and breadth: Architecture, Construction, Environment, Geotechnics, Hydraulics, Regional and Urban Planning, Structures, Systems and Management, Transport Systems and Water Resources.

CERIS was formally created in 2015 to integrate three centres, namely CEHIDRO, Centre of Hydraulics, Water Resources and Environment, CESUR, Centre for Urban and Regional Systems, and ICIST, Institute of Structural Engineering, Territory and Construction. They are hosted by the Department of Civil Engineering, Architecture and Georresources (DECivil), Instituto Superior Técnico (IST), University of Lisbon (UL). CERIS is a unit of the National Science and Technology System registered with Fundação para a Ciência e a Tecnologia (FCT), the Portuguese research-funding agency.

This is the third report on the scientific activity of CERIS after its creation. Besides consolidating the 2017 reports of its founding centres, it defines the positioning of the new unit in the national context and addresses issues on organization and operation, particularly in what concerns the integration of scientific objectives and the promotion of internal cooperation. Equally important is to analyse the 2017 performance indices and to ponder on their evolution.

To that effect, this report is organized in four main parts. The first focuses on the unit description, including an overview of CERIS and the founding centres, as well as a description of CERIS internal organization, governance structure, technical and administrative staff and supporting laboratory facilities. The second part refers to research objectives, namely the general objectives of CERIS and the specific objectives of the research groups. The third part reports the main achievements in 2017 grouped in three levels: CERIS, research centre and research group. Global figures are presented in terms of publications in ISI/Scopus journals, concluded PhD theses and research and consultancy funding. The last part describes the programmed research for 2018 of each research group.

The main points the Executive Board wishes to stress are the following:

- 1) In terms of governance and operation, the merging of centres with different cultures and practices has been demanding, as expected, and confirmed the need to engage an expert in management of Science and Technology and to seed the organization of specialized supporting services.
- 2) In what regards the breadth and scope of the research, the activities reported by the research groups indicate the need to contain the number of topics and actions, in line with the proposed thematic strands and work areas.
- 3) In 2017, CERIS researchers maintained their levels of national and international visibility. They participated in the organization of 43 (23) international (national) events and in the scientific committees of 150 (63) events. Membership of editorial boards remained strong (127 international and 39 national, of which 20 Associate Editor and 4 Editor-in-Chief roles in international journals), as well as the participation in technical committees for drafting codes and standards (78 national and 70 international).

- 4) In global terms and in a community involving quite different cultures of reporting research results, the previous 10-year period of sustained increase in publication in ISI/Scopus journals was held in 2017, with a ratio of 2.3 per PhD member. The ratios for publication in conference proceedings were 0.6 and 2.7 per PhD member in national and international conferences, respectively.
- 5) The number of PhD theses concluded in 2017 (36), as well as the number of on-going co-supervised doctoral students (219 registered in IST-UL and 78 in other institutions), have also been increasing over the last decade. The ratios per PhD member (0.3 concluded theses and 2.9 supervised or co-supervised doctoral students) are approaching target values. The distribution of PhD students is heterogeneous in terms of scientific areas and number of students per supervisor.
- 6) The overall trend for improvement results from the involvement of CERIS in doctoral programs (three coordinated by IST-UL, three in joint participation with other Portuguese universities and four under international consortia, namely through the Portugal-MIT and the IST-EPFL Lausanne Joint Doctoral Initiative). Six of these courses are FCT funded until 2021, mainly through doctoral grants.
- 7) The results summarized above reflect the success CERIS had in securing research and contract funding in the recent past. Maintaining or improving the 2017 performance in the near future may be influenced by the after effects of the economic crisis, by policies on regional funding that impair the Lisbon area and by the grading CERIS will be awarded in the 2017-18 FCT evaluation of the Portuguese research units, still in progress. The FCT grading determines the allocation of core funding, constrains the access to public competitions and conditions ranking in competitive bidding.
- 8) The impact of the economic crisis on the capacity of CERIS to secure consultancy projects still endures, yet some slight recovery is occurring (17% increase relative to 2016). Funding from contracted research remained relatively stable from 2011 to 2015 (with a reduction in 2014) and decreased since then, reaching a minimum in 2017, with a net income equal to 43% of the 2008-2012 average. Reduction of public investment in research coupled with the stringent and unsurmountable restrictions to apply to P2020 funding in the Lisbon region caused losses higher than expected. The very low strategic funding received from FCT also contributed to such figure.
- 9) In 2008-2012, the income sources were balanced, with 54% of the budget sourced from competitive research funds and 46% from contracted research. The 2017 budget (ca. 1.85 M€) was 41% of the 2008-2012 average (ca. 4.3 M€) and the profile of the budget changed. In 2017, 46% of the budget was sourced from competitive research and 54% from contracted research. It is worth mentioning that these values have been relatively unstable in the last few years.
- 10) These changes were caused by the conjugation of the adverse conditions identified above. FCT has launched a new evaluation of the research units in late 2017 - beginning of 2018. CERIS must regain - through internal investment policies - the leading position in the Built and Natural Environment sector, as this ranking directly constrains the core funding annually allocated by FCT and the competitiveness of the unit in most national competition for research funding, from doctoral and post-doctoral grants to RD&I contracts.

## 1. UNIT DESCRIPTION

This section presents an overview of the CERIS research unit and of its founding research centres and defines the positioning of CERIS in the National Science and Technology System. The second part of the section defines the organization of CERIS, profiles its research, technical and administrative staff and identifies the supporting laboratory facilities and the main instruments used by CERIS to promote knowledge transfer activities. The section closes with the definition of the criteria used to analyse the scientific profiles and the performance indices presented in Sections 2 and 3.

### 1.1 General description

Statutorily, CERIS - Civil Engineering Research and Innovation for Sustainability - is a research unit of Instituto Superior Técnico (IST), University of Lisbon (UL), hosted by the Department of Civil Engineering, Architecture and Georresources (DECivil) and integrated in IST-ID, the Association of Instituto Superior Técnico for Research and Development. IST-ID is a private non-profit institution, which primarily aims at carrying out Science and Technology activities, fostering knowledge transfer and promoting the involvement of national and foreign researchers in RD&I activities and projects in their areas of expertise.

Although CERIS was formally created in 2015, through government dispatches 7822/2015 and 12360/2015, its formation as an RD&I unit registered with Fundação para a Ciência e a Tecnologia (FCT), the Portuguese research-funding agency, was proposed in the framework of the 2008-2012 evaluation of the National Science and Technology System, as the merge of three centres of DECivil, namely: CEHIDRO (Centre of Hydraulics, Water Resources and Environment), CESUR (Centre for Urban and Regional Systems) and ICIST (Institute of Structural Engineering, Territory and Construction). Their integration in CERIS enhances a comprehensive thematic coverage, in depth and scope, and promotes synergies in the inherently multidisciplinary Built and Natural Environment sector, which they previously addressed in a non-integrated manner.

At the end of 2017, CERIS joined the expertise of 115 PhD members and 104 PhD collaborators (this distinction is explained below) and 244 non-PhD researchers (PhD students enrolled at IST). CERIS has no parallel in the national context in what regards size and scope, and has the profile and the critical mass needed to attain a strong international presence in the sector. This key-driver for the creation of CERIS was set on a wider vision of the national research system and results from discussions initiated in 2010 on national and international prospects. It was based on the ASCE report 'The Vision for Civil Engineering in 2025' and framed by three key documents: 'Europe 2020', 'Horizon 2020' and 'Portugal 2020'.

The mission and objectives of CERIS and the policy guidelines address the needs of the sector in research and knowledge transfer. They are set under the guiding principle of basing research and innovation on PhD programs while exploiting the diversity of profiles of its members. This diversity is instrumental to promote the different forms of knowledge transfer practiced by CERIS, ranging from continuous training and skills development to direct support to public institutions and industrial and service companies. The merging of the founding centres into CERIS is supported by new policies on membership, work organization and

restructuring of their research lines into thematic strands that directly derive from national and EU directives. Their research is typically based on mathematical modelling, experimentation and fieldwork.

## **1.2 Research centres**

The formal structuring of the research based at DECivil in three centres dates back 40 years with the creation of CESUR in 1975. CMEST, a Structural Engineering centre, and CEHIDRO were created in 1981 and adapted to embrace other areas of research, mainly due to two expansions of DECivil.

ICIST was created in 1981 to absorb research in Construction and later hosted the area of Architecture, introduced in IST in 1998. In 2010, DECivil integrated the former Department of Mining and Georresources, where research was organized in two centres, namely CERENA (Natural Resources and Environment Centre), created in 2006, and CVRM (Geo-Systems Centre), created in 1972. CVRM merged with CEHIDRO in 2012. Thus, the research at DECivil is presently structured in two units, CERENA and CERIS, the latter being the 2015 merge of CEHIDRO, CESUR and ICIST. During 2017, the Architecture and Urbanism members of CERIS decided to form a new research unit and independently apply for funding in the 2017-18 FCT evaluation of the Portuguese research units, but their activity in 2017 is still included in this report.

### **CEHIDRO | Centre of Hydraulics, Water Resources and Environment**

CEHIDRO develops research and consultancy in the areas of hydraulics, water resources and environment. In 2017, CEHIDRO had 19 PhD members, 13 PhD collaborators and 85 PhD students, for a total of 117 researchers organized in two research groups (RG): Pressurised, Fluvial and Maritime Hydraulic Systems (RG2); Environment, Water Resources and Water Services (RG3).

### **CESUR | Centre for Urban and Regional Systems**

CESUR combines the areas of systems engineering and operational research, transport infrastructure systems and policies, and urban, regional and environmental systems. In 2017, CESUR had 25 PhD members, 35 PhD collaborators, 82 PhD students, for a total of 142 researchers. CESUR's activity is organized in three RGs: Urban Planning and Environment (RG1b); Systems and Management (RG4); Transport Infrastructure, Systems and Policy (RG5).

### **ICIST | Institute of Structural Engineering, Territory and Construction**

The core areas of ICIST are Structural Engineering, Construction and Architecture. In 2017, ICIST comprised 71 PhD members, 56 PhD collaborators and 173 PhD students, for a total of 300 researchers, organized in three RGs: Architecture (RG1a); Studies in Construction (RG6); Structures and Geotechnics (RG7).



### 1.3 National positioning of CERIS

Because of the 2013 international evaluation of the National Science and Technology System, FCT selected CERIS and three other units operating in the Civil Engineering sector as eligible for funding, namely CONSTRUCT, hosted by University of Porto, ISE, jointly hosted by University of Coimbra and University of Minho, and RISCO, hosted by University of Aveiro. These units are profiled in Table 1 in terms of areas of operation and Integrated Members, a classification of researchers introduced by FCT to define the core team of each unit.

**Table 1 | Profile of Civil Engineering research units in 2017\***

Domain	CERIS	CONSTRUCT	ISE	RISCO
Architecture	✓			
Construction	✓	✓	✓	✓
Environment	✓			
Geotechnics	✓	✓	✓	
Hydraulics	✓			✓
Regional and Urban Planning	✓			
Structures	✓	✓	✓	✓
Systems and Management	✓			
Transport Systems	✓			
Water Resources	✓			
Number of Integrated Members (2013)	92	46	29	17

\* Based on the most recent available public information

FCT regularly promotes international evaluations since 1996. CEHIDRO, CESUR and ICIST had the highest assigned ranking in the areas they operate with the grade of Very-Good for a top mark of Excellent in all previous evaluations (the grading system included Excellent, Very-Good, Good and Poor). The 2013 evaluation was highly disruptive in terms of criteria and methodology. This particular exercise motivated, for the first time, a widespread rejection in the research community, both individually and institutionally, from units to their host universities and across all scientific areas.

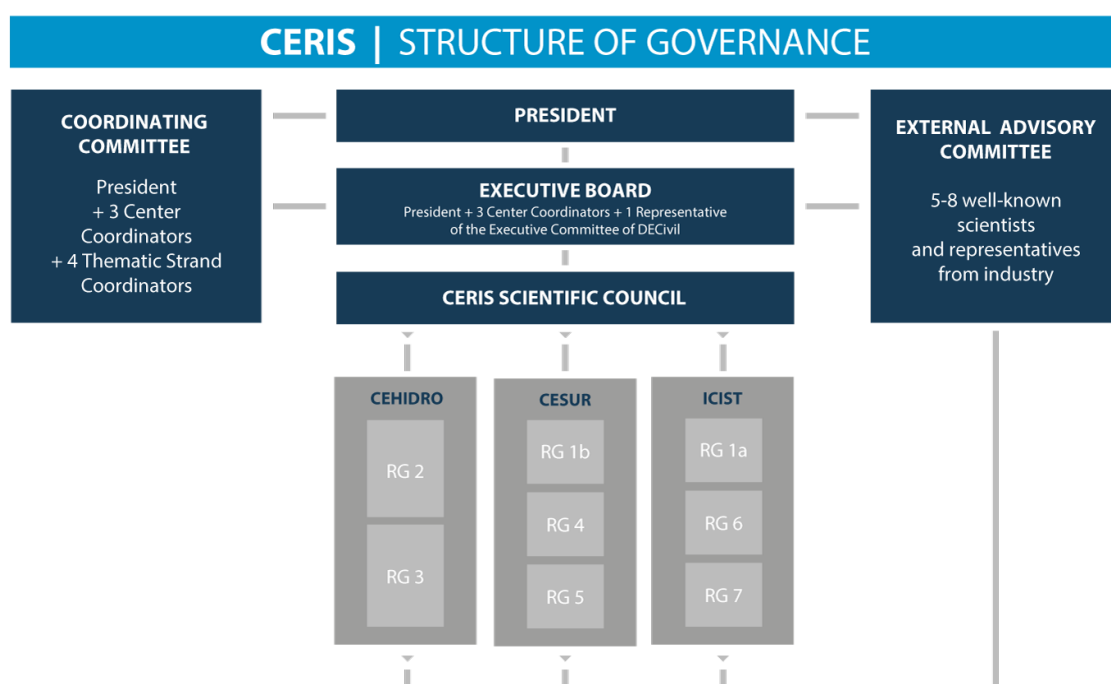
The disruption introduced in the 2013 evaluation is best illustrated by a sudden change of paradigm: in all evaluations held since 1996, Engineering units awarded the top grade of Excellent were many in all areas but in Civil Engineering, where there was none; in the 2013 evaluation, there were no Engineering units awarded the new top grade of Exceptional in any area except for Civil Engineering, where there was one (the new grading system included Exceptional, Excellent, Very-Good, Good and Poor).

CERIS had the leading position in the first stage of the 2013 evaluation with the closest competing Civil Engineering units dropping to relatively distant second and third positions. They had shared the top rank in the previous evaluation, held in 2007. Surprisingly, CERIS fell two positions in the second and final stage of the evaluation process, with the grade of Very-Good. CERIS disputed the result of the 2013 evaluation on

the grounds of being objectively unequal in treatment, partial in judgement and unjust in relative merit, placing CERIS in an unfairly difficult position in all forms of competition held since 2014 and up to when the next international evaluation of the research units. At the end of 2017, FCT launched a new evaluation, independent from the previous one, which will be completed until the end of 2018.

### 1.4 Organization

The organic structure of CERIS meets the recommendations set by IST and FCT. It consists of the President, the Executive Board, the Scientific Council, the External Advisory Committee and the research units, as presented in Figure 1.



**Figure 1 | Structure of governance in 2017**

The President of CERIS is responsible for the overall CERIS management. He/she is assisted by the Executive Board and, whenever necessary, by the Scientific Council Advisory Board. He/she chairs the Executive Board, as well as the meetings of the Scientific Council Plenary and Advisory Board.

The Executive Board assesses, assists and promotes the policies on cooperation through coordination and is composed of five members: the President of CERIS, the Coordinators of the research centres and the Vice-President for Research of DECivil. In the current Executive Board (Table 2), the CESUR Coordinator is responsible for administrative, financial and project management matters, and for the definition of the strategic plan. The ICIST Coordinator is in charge of scientific affairs, the promotion of R&D initiatives and internationalization. The CEHIDRO Coordinator is responsible for image, communication and dissemination.

The Scientific Council is composed of researchers that comply with curricular selection criteria, mainly set

on scientific production. Yearly, the Scientific Council approves scientific reports and plans, as well as financial reports and budgets. It may delegate competences on the Advisory and Executive Boards, but it ultimately rules all relevant matters of CERIS. The Scientific Council Advisory Board includes the members of the Executive Board and the Coordinators of Thematic Strands. Its main competence is to design and supervise the strategic program of CERIS. The thematic strands structure the scientific activity developed by the 7 research groups. Their coordinators in 2017 are identified in Tables 3 and 4.

**Table 2 | Executive Board**

Position	Researcher
CERIS President	Jorge de Brito
CEHIDRO Coordinator	Maria Manuela Portela
CESUR Coordinator	Rosário Macário
ICIST Coordinator	João Ramôa Correia
DECivil Vice-President for RD&I	Luís Calado

**Table 3 | Thematic Strands**

Domain	Coordinator
Product Development in Civil Engineering Industries	Fernando Branco
Risk and Safety in Built and Natural Environments	João Abreu e Silva
Rehabilitation of Built and Natural Environments	Eduardo Santos Júlio
Response to Natural and Societal Changes	Fernando Nunes Correia

**Table 4 | Research Groups**

Group	Designation	Coordinator	Centre
RG1	Architecture, Urbanism and Territory	Teresa Heitor	ICIST + CESUR
RG2	Hydraulics	António Pinheiro	CEHIDRO
RG3	Environment and Water Resources	José Saldanha Matos	CEHIDRO
RG4	Systems and Management	Rui Cunha Marques	CESUR
RG5	Transportation Systems	Luís Picado Santos	CESUR
RG6	Studies on Construction	António Moret Rodrigues	ICIST
RG7	Structures and Geotechnics	Eduardo Júlio	ICIST

The External Advisory Committee of CERIS consists of well-known scientists and representatives from the industry with a recognized knowledge and experience of the challenges faced by institutions with similar missions and objectives. Besides advising on strategic planning and on long-term perspectives, its main competence is to periodically assess the quality and the relevance of the scientific activity of CERIS, the adequacy of its organization, the quality of the scientific environment, the level of internationalization of its activities and its performance in the transfer of knowledge and technology and dissemination. The current composition of the External Advisory Committee is defined in Table 5.

**Table 5 | External Advisory Committee**

<b>Advisor</b>	<b>Institution</b>
Alessandro Damiani	Former Director DG Research, European Commission   Italy
Anton Schleiss	École Polytechnique Fédérale de Lausanne   Switzerland
Kypros Pilakoutas	University of Sheffield   UK
Michael Forde	University of Edinburgh   UK
Rita Moura	Portuguese Construction Technology Platform   Portugal
Werner Rothengatter	Karlsruhe Institute of Technology   Germany

## 1.5 Research staff

According to CERIS rules and regulations, researchers are classified as *collaborators*, *members* and *integrated members*. Members are PhD researchers that meet the productivity criteria set by the Scientific Council of CERIS. Typically, collaborators are PhD students and specialists employed by firms and public services and agencies. This designation also includes PhD researchers that did not meet the productivity criteria set by the Scientific Council in each year. Integrated members are selected amongst PhD members to identify the core team of the unit, as requested by FCT in 2013.

The productivity criteria are based on the research component of the system of academic evaluation set by IST for each three-year period of evaluation, which basically values publication of papers (and the number of citations), supervision of PhD theses, coordination and participation in concluded competitive research projects and knowledge transfer. In 2015, the Scientific Council of CERIS decided to set the minimum requirement to be proportional to the grade of Excellent in the IST system of evaluation.

The current minimum requirements were increased by 30% in 2016 and again by 10% in 2017. Presently, and assuming that no other scientific activity is reported, a PhD researcher would reach the 2017 membership conditions publishing in a Quartile 1 (Q1) ISI journal an average of 1.1 single-author paper per year, or an average of 1.3 (1.6) two- (three-) author papers per year. The grading of the academic evaluation system strongly encourages publication in journals with high impact factors.

In this report, members of the Scientific Council are referred to as 'PhD members'. The term 'PhD researchers' combines PhD members and PhD collaborators. The term 'PhD students' combines PhD students registered in IST-UL (identified as CERIS-IST PhD students) with PhD students registered in other institutions (identified as External PhD Students). They include the students that concluded their doctoral programs in 2017. The 2017 distribution of researchers is summarized in Table 6. They include academic staff of UL and of twelve other universities and polytechnics<sup>1</sup>, besides private companies and foundations.

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<sup>1</sup> U. Algarve, U. Beira Interior, U. Évora, U. Nova de Lisboa, U. Madeira, Instituto Superior de Engenharia de Lisboa, Instituto Superior de Engenharia de Coimbra, Instituto Politécnico de Setúbal, Instituto Politécnico de Leiria, U. Estadual Campinas (Brazil), University College London, University of Western Australia.

**Table 6 | Profile of research staff**

Centre	Integrated members	PhD researchers		PhD students	
		Members	Collaborators	CERIS-IST	External
CEHIDRO	20	19	13	66	19
CESUR	19	25	35	63	19
ICIST	53	71	56	122	51
<b>CERIS</b>	<b>92</b>	<b>115</b>	<b>104</b>	<b>244</b>	<b>89</b>

## 1.6 Administrative and technical staff

In 2017, CERIS and CERENA shared with DECivil the support of administrative staff, namely accounting services and secretariat, and technical staff assigned to computational and experimental laboratories.

The accounting service is staffed by two employees posted from the central services of IST and four employees from ADIST (a private not-for-profit IST association). This resource pooling arrangement seems to satisfy all parties involved, DECivil, CERIS and CERENA. However, there have been difficulties caused by the IST policy of centralizing the management of internationally funded research projects.

Researchers frequently invoke insufficient secretarial support. Four are assigned to CESUR, two to CEHIDRO and the one assigned to ICIST is shared with the Executive Board of CERIS. Resource pooling in this context is harder to assess because it is difficult to isolate duties of staff formally assigned to DECivil.

Another difficulty CERIS faces, endured by its founding centres well before the merge and caused by a long-established freeze on hiring, is the inadequacy of the pool of technical staff assigned to the operation of its computational and experimental laboratories, as shown in Table 7. This staff is complemented by the DECivil Laboratories Coordinator, supported by a joint supervisor for the Structures, Construction and Geotechnics laboratories (LERM, LC and LABGEO). A good part of the day-to-day operation is supported by PhD researchers and students, well beyond training needs.

**Table 7 | Laboratories and technical staff**

Laboratory	Staff (no.)
Laboratory of Architecture (ISTAR)	-
Laboratory of Computational Mechanics (LMC)	1
Laboratory of Construction (LC)	2
Laboratory of Geotechnics (LABGEO)	1
Laboratory of Hydraulics and Environment (LHE)	1
Laboratory of Strength of Materials and Structures (LERM)	2
Laboratory of Transport Infrastructures (LTI)	1

The major difficulty CERIS faces in the present context is the inexistence of administrative and technical staff adequately trained in management of science and technology activities. To mitigate the consequences of this limitation, CERIS created work groups, staffed by PhD researchers, which should originate the services to be set up when the freeze on hiring is waived.

## **1.7 Facilities**

The research methods adopted by CERIS include mathematical and numerical modelling, laboratory experimentation and *in situ* studies. CERIS is equipped with up-to-date hardware and software and the experimental facilities are adequately equipped. The main difficulties in this context are the heavy and limitative constraints on procurement, acquisition/renovation and maintenance/calibration of equipment caused by Government austerity measures.

Experimental PhD projects are supported by the laboratories identified in Table 7 and by the experimental facilities of Laboratório Nacional de Engenharia Civil (LNEC), one of the best-equipped Civil Engineering laboratories in Europe. CERIS does not duplicate costly equipment available there, because LNEC is located within 2 km of IST and institutional collaboration is duly protocolled.

## **1.8 Instruments for transfer of knowledge**

Specialized consultancy and advanced training are the two main ways CERIS promotes knowledge transfer. CERIS members offer a large and diversified set of specialization courses through FUNDEC, the advanced training instrument of DECivil, a private partnership with the major companies operating in the Civil Engineering sector created in 1995. Consultancy is regulated in terms of conflicts of interest and unfair competition and can be directly contracted with CERIS or through FUNDEC or IST.

## **1.9 Analysis of the scientific activity**

The analysis of the activity in 2017 presented in this report is set within the framework of the statutory objectives of CERIS and centred on the content of the research, the organization of the research and the evolution of scientific productivity indicators.

Content of the research is addressed in Section 2, where the thematic strands that structure the research activity are defined, as well as their main work areas. The areas of activity of the research groups in 2017 are also summarized to support the analysis of three key aspects in a new unit merging centres that used to operate independently: the 2017 profiles of the research groups, their organization and the existing and planned forms of internal cooperation. The identification of these aspects should sustain internal policies on membership and internal funding initiatives to promote cooperation and focusing of the research.

The information summarized in Section 3 covers a wide range of research activity indicators, namely on theses and publications, visibility and recognition of the research, and research and consultancy contracts. The analysis of the 2017 results is set on the evolution in time (since 2008) of the number of researchers, of the capacity to secure research and consultancy funds and of two main activity indicators, namely

completed PhD theses and publication of papers in ISI/Scopus journals, listed in Annexes A and B, respectively.

Performance of research units is usually assessed in terms of production rates per team member, which implies a clear definition of the population of the research team, namely integrated members, PhD members and PhD researchers, as summarized in Table 6. It is recalled that the distribution presented there follows the selection criteria approved by the Scientific Council of CERIS in 2015.

The production rates are presented in terms of PhD members and in some instances in terms of PhD researchers to stress the importance of the internal policies on membership. Those rates are presented in global terms and at unit level.

The same information at group level is available but is not presented here. The diversity of the profiles of PhD collaborators can be high within a group and across groups, ranging from non-academic experts to young PhD researchers; therefore, the analysis at group level would imply an effort in detailing and justification that could easily fall into individual assessment, well out of the scope of this report.

## 2. RESEARCH OBJECTIVES

This section defines the institutional objectives of CERIS and the thematic strands that anchor the research activity. It is also used to characterize the areas of activity of CERIS research groups in 2017, as it is essential to assess the relevance and viability of the strategic and operational objectives.

The identification of the thematic strands and of their supporting work areas played a central role in the decision to merge CEHIDRO, CESUR and ICIST. The option has been to define the thematic strands in sufficiently broad terms and to select priority work areas. Their relevance in content and the adequacy of internal expertise should guide the progressive realignment of the activities planned at group level through the periodic reassessment of strategic and operational objectives and of the supporting internal seeding programs.

### 2.1 Institutional objectives

The research objectives of CERIS are set to comply with its statutory mission: “To create and disseminate scientific knowledge and to promote innovation in the Built and Natural Environment sector through the active involvement in fundamental and applied research, at both national and international levels, and to enhance higher education and research training”. To accomplish its mission, CERIS operates under a set of objectives and organizes its activity in thematic strands selected according to national and European policy guidelines.

CERIS coordinates, under the same host institution, knowledge and skills in the Built and Natural Environment sector under the following objectives: (i) to promote quality research based on PhD programs; (ii) to transfer its expertise by providing specialized training, services and consulting; (iii) to ensure a wide dissemination of its results.

To attain its main objective, the policy of CERIS is to organize the PhD programs in the framework of national and international networks and consortia and to integrate doctoral theses in competitive research funding projects. CERIS also benefits from the direct participation of IST in international networks and programs set up to promote the mobility of students and researchers.

In what regards on-going specialized training, CERIS participates in international initiatives promoted by IST and cooperates with national professional associations. To develop mutually beneficial relationships with industrial and engineering firms, central and local administration and with governmental agencies, CERIS focuses on the formulations of public and private policies and on innovation programs that address specific needs of the sector, namely through the Portuguese Technological Platform for Construction, the Portuguese Water Partnership and the Sustainable Habitat Cluster.

CERIS values the dissemination of research results through the best-ranked journals and the best-established conferences. They have a decisive impact on recognition and visibility and, consequently, on the engagement in contracted research and the recruiting of young researchers. The partnerships mentioned above play an important role in knowledge transfer initiatives and are instrumental to enable a closer relationship with public and private institutions.



## 2.2 Thematic strands

The interdisciplinary knowledge in the field of the Built and Natural Environment addresses issues centred on the Construction Industry, namely structural rehabilitation, safety and security and innovation regarding eco-efficient materials, solutions and technologies, and encompasses subjects such as urban and regional planning and management, mobility of people and freight, environment and water resources planning, management and policy, and water services, including drinking water distribution, sewage treatment and hydraulic infrastructure. Moreover, they include dimensions that cut across several areas, such as strategic environment assessment, systems modelling and optimization, as well as decision processes, relevant public policies and governance issues.

In this context, and taking into consideration national and European policy guidelines, the following thematic strands (TS) have been established in 2013 to structure the activities of CERIS:

- TS1: Product Development in Civil Engineering Industries;
- TS2: Risk and Safety in Built and Natural Environments;
- TS3: Rehabilitation of Built and Natural Environments;
- TS4: Response to Natural and Societal Changes.

**Product Development in Civil Engineering Industries** embraces research activities whose main purpose is to improve the competitiveness of civil engineering industries, by developing innovative products and procedures, and by improving the efficiency of existing ones. The applied research to be conducted focuses on the development of projects with a strong emphasis on "idea to business", implying a robust involvement of industrial partners and making use of the interdisciplinary nature of CERIS. The deepening of existing collaborations with Industry is encouraged. The Portuguese Technological Platform for Construction (PTPC), whose university-industry work groups are already developing proposals for a wealth of new projects, is an important partner in this context.

**Risk and Safety in Built and Natural Environments** focuses on the reduction of risk to people, the environment, and natural and built heritage that may be affected by the occurrence of extreme events, either natural, such as floods, droughts, earthquakes, wind storms, and tsunamis, or due to man's activities, such as accidental pollution, deficient structures and infrastructures, blasts and fires. Both environmental hazards and manmade hazards may have devastating effects on the built and on the natural environment, namely on natural resources. Hazard and risk assessment, as well as the development of structural and non-structural safety measures is a major societal challenge in a rapidly changing world, with people concentrating in large urban centers and with growing exploitation of limited natural resources.

**Rehabilitation of Built and Natural Environments** stands out as the new paradigm of the construction sector. New knowledge and skills, gathered through interdisciplinary activity, are needed to respond to current demands. The main goals include reducing risks and ensuring safety, as well as promoting more efficient life cycle management of energy and natural resources, as a means to foster both urban cohesion and the protection of natural and cultural heritage. This thematic strand seeks to mobilize activity within the CERIS research groups in the field of rehabilitation, and to promote synergies between them to carry

out research at the forefront of existing knowledge.

**Response to Natural and Societal Changes** addresses issues related to the characterization, mitigation and adaptation to natural and societal changes, as they induce stress or even ruptures in the “business as usual” approach to the built and natural environment, especially in what concerns the relevant policies, procedures and design and operation of infrastructures for a sustainable interaction between man and nature. Climatic change is of great importance as a driver, forcing adaptation measures in virtually all areas of economic activity and social life, and aggravating all the pre-existing problems caused by social and economic changes.

### **2.3 Research areas**

The main areas of work selected in each thematic strand are the following, as defined by their coordinators:

#### **Product Development in Civil Engineering Industries**

- (i) Development of eco-efficient, high-performance and durable cementitious materials and products, for both new construction and rehabilitation.
- (ii) Advanced composite materials and products for civil engineering applications.
- (iii) Development of components, devices and software to improve the seismic performance of civil infrastructure.
- (iv) Sensors, intelligent systems and knowledge-based management infrastructure systems, in what concerns improved safety, maintenance and management procedures.
- (v) Improvement of products and project efficiency, including procedures for life cycle analysis, procedures for conflict management and negotiation, analysis of private and public values and use of e-business and e-procurement platforms.
- (vi) Development of synergic management to sustainable tourism destination - Lidera destinations (to improve product efficiency and performance).
- (vii) Improvement of natural treatment systems, through pilot facilities, to define best procedures when facing seasonal interruptions and to determine maximum load capacity.

#### **Risk and Safety in Built and Natural Environments**

- (i) Risk assessment of natural and man-made hazards, mainly to support of decision making on the allocation of budgets for safety improvement works.
- (ii) Engineering expertise for improving safety of people and the environment, namely the development of solutions and techniques for improving construction robustness and resilience, as well as for the structural protection, strengthening and rehabilitation.
- (iii) Prevention, preparedness and management of risk considering natural hazards and climate change scenarios, in what concerns non-structural measures related with management, elaboration of risk prevention, preparedness plans and operational and management procedures.

#### **Rehabilitation of Built and Natural Environments**

- (i) Enhancement of the spatial functionality, energy efficiency and structural performance of civil

infrastructures, including the improvement of seismic and fire resistance.

- (ii) Study of deterioration processes and development of advanced inspection and monitoring techniques aiming at enhancing both durability and safety of civil infrastructures.
- (iii) Development of urban management models to establish financing systems of urban rehabilitation and public investments, and flexibility and efficiency of the existing transport network infrastructure and management.
- (iv) Rehabilitation of natural and transformed water bodies, namely rivers, lakes, reservoirs and aquifers, and improvement of the flexibility and efficiency of the existing water infrastructure and management systems, mainly in what concerns water supply and wastewater services.

### Response to Natural and Societal Changes

- (i) Understanding the complexity of natural and societal changes, mainly in what regards adaptation and resilience, competition and mitigation, path dependence, emergence, self-organization and metabolic mechanisms.
- (ii) Improving governance, seeking better integration of policies, new flexible planning and management tools, searching for new methods, tools and devices for efficiency, economy and equity, concerning energy, resources and the used materials.
- (iii) Enhancing the tools to respond adaptively to natural and societal changes, in what concerns information and communication technologies, computation and network systems, providing the platform for designing more intelligent and interconnected tools, and smarter buildings, infrastructures and services.

The main areas of work selected in each thematic strand reflect the number of research groups involved in core and complementary topics, as shown in Table 8. This information is complemented in the next section with data on existing and expected forms of cooperation at group level.

**Table 8 | Groups participating in thematic strands**

Thematic strand	RG1	RG2	RG3	RG4	RG5	RG6	RG7
Product Development	✓			✓	✓	✓	✓
Risk and Safety	✓	✓	✓	✓	✓		✓
Rehabilitation	✓	✓	✓	✓	✓	✓	✓
Response to Changes	✓		✓	✓	✓		

## 2.4 Activity of research groups

The following description describes, for each research group, its main area of interest and the main and the subsidiary topics addressed in 2017, as defined by their coordinators. The distribution of PhD students considers CERIS-IST students (registered in IST-UL) and external students (registered in other institutions and co-supervised by CERIS members). The PhD students are assigned to the groups of their supervisors and co-supervisors (in the CERIS overall figures repetitions resulting from this criterion have been eliminated). Information about RG1 is divided into two sub-groups, namely RG1a (Architecture) and RG1b

(Urbanism), as in 2017 they worked together but formally integrated in ICIST and CESUR centres, respectively.

### **RG1a | Architecture**

#### **6 PhD members | 10 PhD collaborators | 35/8 PhD students (CERIS-IST/External)**

Research focused on complex socio-spatial-technological processes involved in the transformation (remaking and reusing) of built environment, aiming at developing new knowledge and innovation in the field of architecture by reinforcing a cross-disciplinary approach within four domains:

- Re-use of architectural heritage;
- Space-use analysis;
- Adaptive processes;
- Architectural design processes and methods.

In 2017, RG1a members co-supervised doctoral theses developed in cooperation with other schools of U. Lisboa, U. Coimbra and U. Porto, as well as U. Chongqing, and MIT, the latter under a joint initiative. RG1 members cooperated in research with other groups of CERIS (RGs 1b, 4, 5, 6 and 7) and cooperated with researchers in joint projects from other national and international research centres and universities (INESC, LNEC, U. Nova Lisboa, U. Coimbra, U. Lisboa-IST, U. Porto, UCL, UK; Florence and Torino, Italy, U. Chongqing, Hochschule Owl, Germany, ITU, Turkey, U. Antwerpen and U. Leuven, Belgium, U. San Pablo and U. Navarra, Spain) as well as international researchers. They also cooperated as referees for international journals. Research contracts were developed with the Governments of Cabo Verde and Timor, as well as cooperation with foreign universities. A group member acted as external expert for the OECD Centre for Effective Learning Environments and for The World Bank IBR-IDA.

### **RG1b | Urbanism**

#### **6 PhD members | 9 PhD collaborators | 7/6 PhD students (CERIS-IST/External)**

The RG1b objectives and activity are structured along six lines:

- Urban and territorial policies;
- Governance, management, negotiation and contracting;
- Urban morphology, energy and environment;
- ICT in planning;
- Transformation dynamics of territorial systems;
- Theory and practice of spatial planning.

In 2017, RG1b developed research with national institutions (U. Lisboa, U. Évora, U. Lusófona, ISCTE, FCT-UNL), international institutions (U. Barcelona, U. Laguna, U. Valencia, U. Seville, U. Granada, U. Rome, U. Western Australia, U. Queensland, U. Ghent, U. Copenhagen, U. Zagreb, U. Greenwich, U. Leeds, U. Portland, U. Berkeley, U. Beijing, U. Tehran) and international networks (IFHP, AESOP, INTA, ISoCARP, IMPACTS, RedeMOV).

## **RG2 | Hydraulics**

**7 PhD members | 9 PhD collaborators | 33/7 PhD students (CERIS-IST/External)**

The activity of RG2 in 2017 was organized in the following major topics:

### a) Pressurized water systems

- Modelling dynamic effects induced by hydraulic transients in pressurized pipes;
- Fluid-structure interaction in transient pipe flows;
- Design criteria for safe operation of water systems under steady and unsteady state conditions;
- Contributions to energy and hydraulic efficiency.

### b) Fluvial hydraulic structures

- Experimental study on the rock scour due to high velocity plunging jets;
- Experimental research on labyrinth spillways;
- CFD modelling of stepped spillways and sewer drops.

### c) River restoration and management

- Numerical modelling of fish species habitat, river rehabilitation works and fish ways;
- Movement patterns in cyprinids affected by hydropeaking and analysis of hydropower operation;
- Incorporating riparian vegetation modelling experiments into environmental flow regimes.

### d) Sediment transport and river morphodynamics

- Experimental/mathematical modelling of dam-breach, morphodynamics and free-surface flow;
- Experimental study of control of sedimentation in reservoirs induced by turbidity currents;
- Experimental study on scour at bridge piers/abutments and river confluences morphodynamics;
- Laboratory/field characterization of the turbulent hydrodynamics and dynamics of sediment transport associated to gravel-bed river fish habitats and vegetated areas;
- CFD modelling of rough-bed open channel flows.

### e) Ocean waves and coastal and port structures

- Modelling wave-current interaction at local and refined scale with a RANS CFD solver, as well as at regional scales with fully coupling of a 3D circulation model with a wave model;
- Modelling wave-structure interaction with a NLSW model;
- Modelling of tsunamis and storm surges;
- Study of residual agitation inside harbours;
- Modelling of shoreline evolution and study of the influence of the wave field parameterization.

In 2017, RG2 members coordinated and supervised doctoral theses of two FCT funded doctoral initiatives (Table 12) developed in cooperation with other universities (EPFL, Instituto Superior de Agronomia of U. Lisboa) and LNEC. RG2 continued to cooperate in RD&I and consultancy projects with national research institutions (LNEC, U. Perugia, U. Valencia), industrial partners (AdP; AKUT/SKAT, AQUALOGUS) and the water regulator (ERSAR).

Additionally, the group cooperated in projects and scientific supervision with the following foreign institutions: U. Trento, U. Parma, U. Trieste, Università degli Studi di Napoli Federico II and U. Perugia, Italy; U. Uppsala, Sweden; ENIT, Tunisia; UP Valencia, U. Malaga and U. Vigo, Spain; U. Guanajuato, Mexico; U. Campinas, Brasil; Trinity College, Ireland; U. California at Davis and U.S. Bureau of Reclamation, USA; FH Aachen, TU Munich and U. Applied Sciences, Germany; UF Rio Grande do Sul/IPH, Brazil; U. Manchester, UK; Institut National de Recherche en Sciences et Technologies pour L'environnement et L'agriculture (IRSTEA), France; Norwegian University of Science and Technology (NTNU), Norway; U. Catholique de Louvain (UCL), Belgium; U. Cyprus, Cyprus; U. Patras, Greece; U. British Columbia (UBC), Canada. The group develops joint work with RG1b, RG3, RG4, RG5 and RG7 under national projects.

### **RG3 | Environment and Water Resources**

**12 PhD members | 4 PhD collaborators | 33/12 PhD students (CERIS-IST/External)**

The activity of RG3 is focused on the following topics:

- Hydrology and water resources;
- Water policy and governance;
- Impact assessment;
- Managing water and energy links and adaptation of structures and systems to climate change;
- Strategic planning of water services;
- Mathematical modelling of wastewater systems performance, including of constructed wetlands;
- Groundwater pollution and risk assessment;
- Groundwater and ecosystems;
- Aquifer recharge and discharge, water and climate change;
- Stochastic and deterministic groundwater modelling;
- Water and climate change;
- Decision support systems for water catchment management;
- Development of effective methods for risk-based environmental decision-making under uncertainty.

In 2017, joint research work has been developed in different issues of water resources and environment, namely with PO SEUR (Branch of the Environmental Ministry for Managing the Operational Programme for Sustainability and Efficient Use of Resources), respecting operation and maintenance costs of water infrastructures; with the National laboratory of Civil Engineering (LNEC) (namely in water asset management issues); with the Regulatory Authority for Water and Wastes (ERSAR), in regulatory water/wastewater issues and preparing water legislation; with the Portuguese Agency for the Environment (APA) (water resources management and trend analysis of hydrogeological variables); with utilities of the Holding Águas de Portugal (namely Aguas do Tejo-Atlantico) and with the Lisbon Municipality (on urban hydrology/hydrogeology), as well with Oviedo University (on mine water and environment); IHE-UNESCO (groundwater and global change); ESPOL, Guayaquil, Ecuador (decision support systems for water catchment management) ; University of Tunis El Manar, Faculty of Sciences of Tunis (on stochastic and

groundwater numerical modelling) ; U. Antioquia, Colombia (on quantitative hydrogeology) and Cooperation y Regional Government of Lima, Peru (on groundwater modelling of North Peruvian aquifers).

Group members collaborated actively with relevant international institutions, such as the Organization for Economic Co-operation and Development (OECD), the European Water Association (EWA) and the International Water Association (IWA).

## **RG4 | Systems and Management**

### **8 PhD members | 14 PhD collaborators | 27/5 PhD students (CERIS-IST/External)**

Research focused on the processes of evaluation and decision-making on the design, management and operation of complex systems, namely through adequate methodologies, processes and decision support models applied to public services and infrastructure, in the three following major broad domains:

- Project management, procurement and contracting;
- Logistic systems configuration and operation;
- Regulatory pricing policies and performance systems assessment.

Research focused also on Digital and Information Systems in the context of the Built and Natural Environment sector. In 2017, RG6 was particularly concerned with:

- Geomatics and geographical information (ground deformation measure with advanced SAR interferometric methods; spatial analysis problems, namely in location problems and in territorial management; geographic databases);
- 3D City information models and its application to sustainability challenges (solar potential maps; energy management at the neighbourhood level);
- Building information modelling and information management, focusing in particular on European BIM standardization (CEN/TC442) and construction digitization;
- Virtual reality and BIM simulation (virtual reality applications; augmented reality; 3D simulations; energy and emergency simulations; smart buildings management);
- Collaborative and electronic systems (e-business and e-procurement; e-learning and social networks as learning environments);
- Sustainability and construction management support systems (sustainability in long-term infrastructure development and management; sustainable e-procurement; risk assessment and management; construction information management).

In 2017, RG4 cooperated with groups RG1a, RG1b, RG3, RG5, RG6 and RG7 and with researchers from Portuguese institutions (Portuguese Agency for the Environment, ERSAR, ERSARA, U. Lisboa, U. Aveiro, LNEC, U. Évora, U. Algarve, ISCTE, IP Leiria, U. Católica Portuguesa). The research group carried out collaborative work with research centers and institutions from Australia (U. New England, LaTrobe U., U. Southern Cross, U. Western Australia, U. Queensland), Belgium (KU Leuven), Brazil (ABAR, Fundação Getúlio Vargas, Fundação Oswaldo Cruz, U. Brasília, U. Rio Grande do Norte, UF Rio de Janeiro, U. São Paulo), Chile (PU Chile, U. Santiago), Germany (U. Darmstadt), Ireland (U. Limerick), Italy (U. Bocconi, U.





Pisa, U. Verona, Politecnico di Milano), the Netherlands (U. Amsterdam), Spain (U. Barcelona, U. Oviedo), UK (U. Kingston) and USA (Carnegie Mellon U., U. Florida, Cornell U.). Group members collaborated with international institutions, such as the European Investment Bank, the Inter-American Development Bank, The World Bank, Transparency International and OECD. The group participated in several standardization projects, which involved more than 40 companies.

## **RG5 | Transportation Systems**

**11 PhD members | 12 PhD collaborators | 33/9 PhD students (CERIS-IST/External)**

RG5 research focused on the following three main topics:

### a) Road, Airport and Rail Infrastructure Systems

- Methodologies and models to predict degradation and improve maintenance, renewal and investment decisions within the different transport infrastructure systems and across them (integrated asset management);
- Application of nanotechnology and development of low energy asphalt concrete incorporating industrial by-products, with the same structural efficiency as traditional ones for roads and airports;
- New concepts for railway infrastructure design to enhance reliability, availability, maintainability and resilience to natural events;
- Tools and indicators to infrastructure planning and design and technology development to foster sustainable modes in urban environments;
- New life cycle assessment for transportation infrastructures in a low life cycle cost perspective.

### b) Transport Systems Planning and Operations

- Retrofitting transport systems: changing and adapting “old to like-new” transport systems to meet new performance standards while extending the existing ones;
- Adaptable networks through dynamic regulatory schemes managed by advanced ICT technologies and implemented by ITS innovative solutions for infrastructure;
- Microscopic and other type of simulation modelling for the estimate of network safety performance for vehicles (including autonomous), freight and vulnerable users;
- Optimization and simulation of public transport operations under a huge uncertainty for demand and risk analysis to support decision-making in transport system investments.

### c) Strategy and Policy in Transport Systems

- Transport systems and policies for an ageing society;
- New types of integration of public and private transportation modes and services as vehicle-sharing systems;
- Redesign global logistics processes;
- Institutional and Regulatory Framework, Financing and Charging for Transport Systems.

In 2017, and following the previous years, the international activity of RG5 is based on a regular presence in leading international projects with industrial and research partners and/or contractor, namely the



European Schools of TRANSPORTNET, the Portugal-MIT Program, the European Commission, Latin American Schools, namely in Argentina, Brazil, Chile and Colombia, Administrations for Transport Infrastructures (namely SNCF in France and AFIF in Spain), and Volvo (Research and Education Foundation). FCT funded research and I&D contracts were established and are under way with the main transportation actors in Portugal, such as Infraestruturas de Portugal (the national road and railway infrastructure administration), ANA (the manager of the Portuguese international airports), Transportes de Lisboa (bus, metro and Tagus river boat transit administration for the Lisbon metropolitan area), the Lisbon Metropolitan Transportation Authority and several construction and consultancy companies, with the participation of members of other research groups.

### **RG6 | Studies on Construction**

**28 PhD members | 13 PhD collaborators | 51/21 PhD students (CERIS-IST/External)**

RG6 developed research projects in the following domains:

- Construction Materials, Technology and Management Innovation: advanced materials (GFRP, CFRP); waterproofing systems; concrete and mortars technology; construction quality, safety, environmental and health management; virtual reality applications in construction;
- Sustainable Construction: sustainability and deconstruction strategies; sustainable traditional materials; demolition and recycling; recycled aggregates; building physics and passive design; building acclimatization and mechanical systems;
- Monitoring, Rehabilitation and Conservation of the Built Heritage: Inspection, diagnosis, maintenance and rehabilitation systems; maintenance of buildings envelope; conservation of historical building heritage; sensors, technological innovation and structural assessment;
- Fire Design: fire resistance and risk evaluation of cultural heritage.

In 2017, members of RG6 co-supervised doctoral theses developed in cooperation with different departments and schools of national institutions (LNEC, IS Engenharia Lisboa, U. Coimbra, U. Lisboa, U. Minho, U. Nova Lisboa, U. Évora, U. Católica Portuguesa) and foreign institutions (EPFL, ETH Zurich, UE Campinas, UE Maringá, UF Brasília, U Sevilla, U. Cordoba, UP Valencia), Similar cooperation in the development of master dissertations occurred with LNEC and national firms, as well as with different schools and departments of national universities (IS Engenharia Lisboa, ESTBarreiro/IPS, U Lisboa, U Nova Lisboa, IS Engenharia Porto) and foreign universities (ENTPE Lyon, TU Delft, FAU-USP, Liverpool JMU). Joint research projects were developed with LNEG, U. Nova Lisboa, LNEC, U. Lisboa and U. Minho. The most relevant internal collaborations occurred with researchers from RG1a, RG4 and RG7.

### **RG7 | Structures and Geotechnics**

**37 PhD members | 33 PhD collaborators | 45/22 PhD students (CERIS-IST/External)**

The activity of RG7 in 2017 was organized in the following main topics:

#### **a) Finite Element Modelling of Nonlinear Structural Behaviour**

- Analysis of thin-walled members and structures via Generalized Beam Theory (GBT) or



commercial software, numerical/experimental study of the behaviour and design of cold-formed steel members. Considerable in-house expertise in this field, namely on the development, implementation and application of GBT formulations and on cold-formed steel members affected by coupling phenomena involving distortional buckling;

- Modelling of nonlinear material behaviour, often responding to modelling needs of applied research groups, typically using hybrid finite element formulations and applied to (i) damage and fracture constitutive models for masonry, concrete and high-strength concrete; (ii) thermo-chemo-mechanical behaviour of concrete; and (iii) coupled thermal/fluid flow/radiation of advanced materials.

#### b) Earthquake Engineering and Seismology

- Seismic impact in urban areas;
- New techniques for high-resolution imaging of structures beneath dense seismic arrays;
- Evaluation of the potential seismic performance of masonry and reinforced concrete buildings;
- Seismic strengthening solutions for old building walls and adobe and rammed earth constructions;
- Seismic behaviour of old masonry buildings typical of Lisbon historical centre;
- Seismic behaviour of industrial structures and lifelines;
- Modular systems for buildings.

#### c) Structural Concrete

- Development of advanced cementitious materials, including ultra-high performance concretes and eco-efficient concretes;
- Study of structural connections, such as concrete-to-concrete interfaces, steel-to-concrete interfaces and FRP-to-concrete interfaces;
- Structural modelling and development of design models;
- Durability studies, including development of deterioration predictive models, and development of preventive and/or remedial procedures;
- Structural health monitoring;
- Robustness and risk analysis;
- Design applications, from development of innovative solutions for new construction to development of innovative strengthening techniques for existing structures.

#### d) Steel and Composite Structures

- Studies on steel and composite structures with bolted and welded dissipative fuses;
- Development of numerical models to simulate the behaviour of structural members;
- Proposal of design rules for steel and composite structural members;
- Applications to steel and composite buildings;
- Laser technology for innovative connections in steel construction;
- Proposal of design rules for steel hollow sections.

e) Bridge and Special Structures

- Design of steel-concrete composite bridge decks using high strength steel;
- Higher order beam models. Analysis of curved bridge girders and steel-concrete bridge girders; analysis of structures with generic cross-sections considering the displacement field approximated over the cross-section by meshes of two dimensional domains;
- Dynamic analysis of bridges. Response to moving loads; influence of in-plane cross-section deformation. Application of higher order beam models;
- Geometrical and physical non-linear analysis of steel thin-walled structures: Buckling of curved steel plate girder panels with longitudinal stiffeners; Buckling resistance of steel plate girders considering M-V interaction with high compression forces; Stiffeners design for steel and steel-concrete composite bridge decks. Application of higher order beam models;
- Analysis and design of offshore structure.

f) Geotechnics

- Dynamic characterization of soils from small to large strains, including liquefaction;
- Studies on the elastic response measured in resonant column and using bender elements;
- Characterization of the chemo-hydro-mechanical behaviour of clayey and treated soils considering their structure and degree of saturation;
- Behaviour of special foundations (e.g. thermopiles and soils) treated with jet grouting and bacteria;
- Numerical analysis of geotechnical structures involving strong soil structure interaction, e.g. tunnels, retaining structures, piles and thermoactive structures;
- Studies on soils decontamination techniques (e.g. electro osmosis).

In 2017, members of RG7 established new and consolidated existing cooperations, mainly through research projects, including co-supervision of both PhD and MSc theses, with researchers and technicians from different international and national (foreign and Portuguese) entities, namely:

a) Universities and polytechnic institutes - EPFL (Switzerland), Imperial College London (UK), Ludwig Maximilians U. (Germany), MIT (USA), NTNU (Norway), Oregon U. (USA), Oxford U. (UK), Sheffield U. (UK), TU Delft (The Netherlands); TUST (Iran), U. Aveiro (Portugal), U. Bundeswehr München (Germany), U. California (USA), U. Campinas (Brazil), U. Chongqing (China), U. Coimbra (Portugal), U. Dili (East Timor), U. Genoa (Italy), U. Granada (Spain), U. Hong Kong (China), U. Laval (Canada), U. Lusíada (Portugal), U. Madeira (Portugal), U. Michigan (USA), U. Minho (Portugal), U. Nice (France), U. Nova Lisboa (Portugal), U. Padova (Italy), U. Paul Sabatier Toulouse III (France), U. Pavia (Italy), U. Pierre et Marie Curie (France), U. Porto (Portugal), U. Sao Paulo (Brazil), U. Zaragoza (Spain); UFRJ (Brazil), UMR Sisyphe (France), UP. Cartagena (Spain), UP. Catalunya (Spain), A. Militar (Portugal), IPCoimbra (Portugal), IPLeiria (Portugal), IPLisboa (Portugal);

b) Public institutes - CTICM (France), Earthquake Engineering Research Centre (Iceland), ECCS (Belgium), IFPEN (France), INESC (Portugal), Institut de Physique du Globe de Paris (France), Istituto

Nazionale di Geofisica e Vulcanologia (Italy), ITQB (Portugal), LNEC (Portugal);

c) Governmental institutions - OECD (European), Government (S. Tomé and Príncipe), Direcção Nacional de Geologia (Mozambique); National Institute of Meteorology and Geophysics (Cape Verde);

d) Associations - CEN (European), European Association for Earthquake Engineering (European), fib (international), GPBE (Portugal), IBRACON (Brazil), ICOMOS (international), IPQ (Portugal), PTPC (Portugal), SPEHC (Portugal), SPES (Portugal), TRB (USA);

e) Public and private industrial partners - Concremat (Portugal), FIP Industriali (Italy), Infraestruturas de Portugal (Portugal), Itaipu Binacional (Brazil), Lena (Portugal), Postejo (Portugal), PRETENZA (Portugal), Smart Innovation (Portugal), Solancis (Portugal), Spral (Portugal), STAP (Portugal), Taylor Devices (UK), Vamaro (Portugal), Vigobloco (Portugal), VSL (international).

## 2.5 Internal cooperation

It is not straightforward to analyse the information presented above in terms of breadth and scope of the research because specialists have different perceptions in distinguishing primary and subsidiary areas of work, as well as on their linkage with manpower requirements. Both traits in reporting are also visible, in some instances, in the definition of the research programmed for 2017 (Section 4).

These issues were addressed in the earlier international evaluations of the research centres and supported by recommendations to avoid the risk of spreading the research too widely and too thinly by focusing the research though increased internal cooperation. To that effect, the information given in Table 8 is used in Table 9 to identify all potential forms of cooperation in the development of the thematic strands (identified in Table 9 by digits 1 to 4). This overlapping is indicative as one cannot expect direct cooperation between all groups participating in a given thematic strand.

**Table 9 | Potential group cooperation in terms of the thematic strands**

Groups	RG1	RG2	RG3	RG4	RG5	RG6	RG7	Centre
	<b>RG1</b>	2; 3	2; 3; 4	1; 3	1; 3	1; 3	1; 3	<b>ICIST+CESUR</b>
		<b>RG2</b>	2; 3	2; 3	2; 3	2; 3	2; 3	<b>CEHIDRO</b>
			<b>RG3</b>	2; 3	2; 3; 4	2; 3; 4	2; 3	<b>CEHIDRO</b>
				<b>RG4</b>	1; 3	1; 3	1; 3	<b>CESUR</b>
					<b>RG5</b>	1; 3	1; 2; 3	<b>CESUR</b>
						<b>RG6</b>	1; 2; 3	<b>ICIST</b>
							<b>RG7</b>	<b>ICIST</b>

1: Product Development in Civil Engineering Industries

2: Risk and Safety in Built and Natural Environments

3: Rehabilitation of Built and Natural Environments

4: Response to Natural and Societal Changes

## 2.6 Profile of research groups

Two main aspects are analysed herein: the engagement of PhD students and the profiles of the PhD collaborators. To support this analysis, the data previously presented on PhD researchers (members and collaborators) and PhD students are recalled in Table 10.

The information presented in Table 10 shows that all centres, especially CEHIDRO, have attained very good ratios of PhD students per PhD member, with an overall ratio of 2.90, near the top of the target value usually set in the range of 2-3. These ratios are not uniform at group level, not even within each centre, with overall extreme values of 1.8 and 5.7 within the different research groups.

**Table 10 | Profile of research centres**

Centre	PhD researchers		PhD students		Ratios per PhD member	
	Members	Collaborators	CERIS-IST	External	PhD collaborators	PhD students
CEHIDRO	19	13	66	19	0.68	4.47
CESUR	25	35	63	19	1.40	3.28
ICIST	71	56	122	51	0.79	2.44
<b>CERIS</b>	<b>115</b>	<b>104</b>	<b>244</b>	<b>89</b>	<b>0.90</b>	<b>2.90</b>

In Section 3 the highest rates in the engagement of PhD students are directly related with structured doctoral programs funded by FCT and coordinated by or with the participation of members of CERIS. The ratio of PhD students is not necessarily linked to the levels of productivity of the research groups. Nevertheless, CERIS must promote internal PhD grants to reach a more uniform distribution of PhD students. These programs should focus on younger PhD researchers facing difficulties in securing funding for doctoral projects.

The second issue addressed herein is the engagement of PhD collaborators. Two main reasons complicate a fair analysis of this issue. The first is the content of the research of each group in what concerns the added value offered by non-academic PhD collaborators. The second is the diversity of their profiles in 2017, combining non-academic experts, researchers in the early stages of their careers and academic staff with low engagement in research because of individual career options.

Data given in Table 10 indicate that the proportion of PhD collaborators is high, particularly in CESUR. The deviation of the ratios at group level is again substantive, within and across centres. CERIS has been dealing with this issue and implemented in 2017 a clear policy on academic staff not meeting the membership requirements on scientific performance. It targeted those who have experienced circumstantial difficulties in raising research funds and has fomented their engagement in doctoral supervision, either by reallocation to better performance teams or through internal doctoral grant programs. It has also limited the probation period for those who do not succeed in those initiatives, as this form of affiliation is statutorily transient. On an opposite direction, it should be noted that the requirement

to be member was increased by 10% in 2017, compared to 2016, which led to a reduction in the proportion (and number) of members.

## 2.7 Reorganization of the research groups

As mentioned above, within the FCT call for funding and evaluation of Portuguese research units, the area of knowledge of Architecture, Urbanism and Territory (RG1) decided to apply independently from the rest of the CERIS research groups. For this purpose, a new research unit was proposed, CiTUA (Centro de Investigação em Território, Urbanismo e Arquitectura). Until the end of 2018, before the results of this evaluation process are homologated, RG1 will remain in CERIS under the same circumstances as before. In 2019 onwards, the remaining research groups will be renumbered as indicated in Table 11.

**Table 11 | Research Groups (before and after the creation of CiTUA)**

Before	Designation	After
RG1	Architecture, Urbanism and Territory	-
RG2	Hydraulics	RG1
RG3	Environment and Water Resources	RG2
RG4	Systems and Management	RG3
RG5	Transportation Systems	RG4
RG6	Studies on Construction	RG5
RG7	Structures and Geotechnics	RG6

### 3. MAIN ACHIEVEMENTS

Because research in CERIS is statutorily based on doctoral training, this section opens with the identification of the doctoral programs staffed by members of CERIS in 2017. The second part of this section summarizes the 2017 activity indicators and the third one the evolution of the main indicators in three main periods: (i) the expansion of the public investment in RD&I, up to 2009; (ii) the economic crisis, since 2010-2011; (iii) the combination of that crisis with the 2013 FCT evaluation of CERIS, from 2013 to 2017. Section 3 closes with the summary of the 2017 research group results.

#### 3.1 Doctoral programs

Besides five Master courses promoted by IST, CERIS researchers are presently engaged in PhD courses leading to nine Doctoral degrees. Students and their supervisors can either select structured, thematic PhD programs or select a combination of PhD-level subjects offered by IST or any other school of UL, or by other universities under protocolled agreements.

The doctoral degrees and the structured PhD programs CERIS is engaged with are listed in Table 12, which includes information on coordination and funding, mostly allocated to doctoral grants. Four PhD programs are offered under international protocols and three under national consortia. One PhD program is IST-interdepartmental and another is jointly promoted by schools of UL.

**Table 12 | Participation in doctoral programs**

Doctoral degree	Structured PhD programs	Observations
Architecture (IST coordinator: A. Tostões) <sup>(1)</sup>		IST-EPFL initiative
Civil Engineering (F. Branco) <sup>(1)</sup>	Eco-Construction and Rehabilitation (Coordinator: J. de Brito) <sup>(1,2)</sup>	Consortium of 5 universities and LNEC
	Analysis and Mitigation of Risks in Infrastructures (R. Bento) <sup>(1,2)</sup>	Consortium of 4 universities and LNEC
	Environmental Hydraulics and Hydrology (A.H. Cardoso) <sup>(1,2)</sup>	IST-EPFL initiative and LNEC
Climate Change and Sustainable Development Policies (J.S. Matos) <sup>(1)</sup>	Climate Change and Sustainable Development Policies <sup>(1,2)</sup>	Consortium of 3 universities (involving 7 schools)
Earth-Resources		
Environment Engineering		Involves 4 IST departments
River Restoration and Management (A. Pinheiro) <sup>(1)</sup>	River Restoration and Management <sup>(3)</sup>	Involves 4 UL schools
Territorial Engineering (F.N. Silva) <sup>(1)</sup>		
Transportation Systems (L.P. Santos) <sup>(1)</sup>	Transportation Systems <sup>(1,2)</sup>	Portugal-MIT initiative

<sup>(1)</sup> Coordinated by CERIS members; <sup>(2)</sup> Funding until 2021; <sup>(3)</sup> Funding until 2020.

CERIS also participates in a structured PhD program on Computational Engineering, originally funded through the Portugal-U. Texas (Austin) initiative. It is not listed in Table 12 because the participation of CERIS is marginal.

### 3.2 Activity indicators

The main scientific outputs of CERIS in 2017 are presented in Table 13:

- (i) 36 concluded PhD theses and 297 in progress (219 developed by CERIS-IST PhD students registered in IST and 78 by PhD students registered in other schools or universities);
- (ii) 320 concluded MSc theses and 281 in progress (master students registered at IST);
- (iii) 32 books (6 as entire book author, 24 as author of book chapters and 2 as book editor);
- (iv) 263 papers published in international journals, among which 257 cited in ISI Web of Knowledge, 6 cited in Scopus database, and 24 papers published in other international journals;
- (v) 307 papers published in international conference proceedings;
- (vi) 66 papers published in national conference proceedings.

**Table 13 | 2017 activity indicators: theses and publications**

ACTIVITIES		CEHIDRO	CESUR	ICIST	CERIS	
Academic research work	PhD theses	Concluded	11	5	21	36
		In progress: CERIS-IST students	59	60	106	219
		In progress: external students	15	17	46	78
	MSc theses	Concluded	48	71	210	320
		In progress	37	69	179	281
Publications	Papers in peer-reviewed journals	International journals: ISI	49	41	169	257
		International journals: Scopus	0	1	5	6
		National peer-reviewed journals	3	0	21	22
	Papers in other journals	International	8	4	12	24
		National	3	4	5	9
	Papers in proceedings	International	85	75	145	307
		National	30	8	30	66
	Books	Entire	1	2	3	6
		Chapters	4	10	12	24
		As editor	0	0	2	2
Reports		6	4	19	29	

The number of papers published in international journals (287 in total) is only slight lower than the number of communications presented in international conferences (307). A few years back this relation was of the order of 1-to-4. The change is due to the emphasis placed on the publication in international archive journals.

The indicators frequently used to assess national and international visibility are summarized in Table 14, namely:



- (i) Membership of editorial board of international journals (127);
- (ii) Membership of editorial board of national (Portuguese and foreign) journals (39);
- (iii) Peer-reviewing for several international journals (888) and national journals (39);
- (iv) Participation in organizing committees of international conferences (43);
- (iv) Participation in organizing committees of national conferences (23).

Other indicators that reflect the visibility and recognition of the scientific activity of CERIS members are:

- (i) 61 invited keynote lectures made in both international and national conferences;
- (ii) 11 recognition awards (national and international);
- (iii) Sustained academic and scientific cooperation with leading national and foreign universities and institutions.

**Table 14 | 2017 activity indicators: visibility and recognition of the research**

ACTIVITIES			CEHIDRO	CESUR	ICIST	CERIS
Membership of bodies for collective guidance of scientific work	Editorial boards of journals	International	18	19	90	127
		National	10	1	28	39
	Conference scientific committees	International	24	35	91	150
		National	20	1	42	63
	Drafting of codes, recommendations	International	5	2	71	78
		National	4	1	65	70
Organization of scientific events - membership of organizing committees		International	8	12	23	43
		National	0	5	18	23
Refereeing journals		International	132	126	630	888
		National	8	6	25	39
Refereeing for funding agencies (national and international)			8	2	36	46
Lectures by invitation in international conferences (plenary, keynote)			6	21	34	61
Lectures and/or organization of scientific or technical workshops, seminars, courses and similar (national and international)			26	85	64	175
Scientific cooperation		International	47	48	100	195
		National	33	14	119	166
Academic exchanges		International	13	23	11	47
		National	4	2	4	10
Awards (national and international)			0	3	8	11

The information presented in Table 15 summarizes the 2017 initiatives to obtain funding through competitive research and consultancy. As shown below in Figure 6, in 2017 the budget secured through competitive research projects (close to 0.85 M€) was nearly 85% of the budget secured through

consultancy (close to 1.00 M€). This means that, even though public research-funding fell sharply (the worst year in record for decades), the funding secured through specialized consultancy and industry-funded projects has slightly increased. The former was caused by the austerity policies applied by the government during the economic crisis (and the aforementioned limitations to obtain regional funding in the Lisbon) and latter reflects some recovery of the Construction sector.

**Table 15 | 2017 activity indicators: research and consultancy contracts**

ACTIVITIES			CEHIDRO	CESUR	ICIST	CERIS
Research grants for projects, sabbaticals, post-doc	International research grants	Submitted	11	9	17	37
		Awarded	3	3	5	11
		In progress	5	11	15	31
	National research grants	Submitted	18	12	39	69
		Awarded	2	2	1	5
		In progress	8	6	32	46
Individual PhD grants		Submitted	1	2	7	10
		Awarded	11	1	24	36
Consultancy projects and industry contract research projects			16	28	41	85

The indicators presented in Table 16 (Other initiatives) justify the following clarifications: a) Models typically are laboratory test-rigs; b) The software applications listed are limited to those accessible in the internet for public use; c) Registration as a national patent must be ensured before submission to international registration in the annual, internal calls promoted by IST.

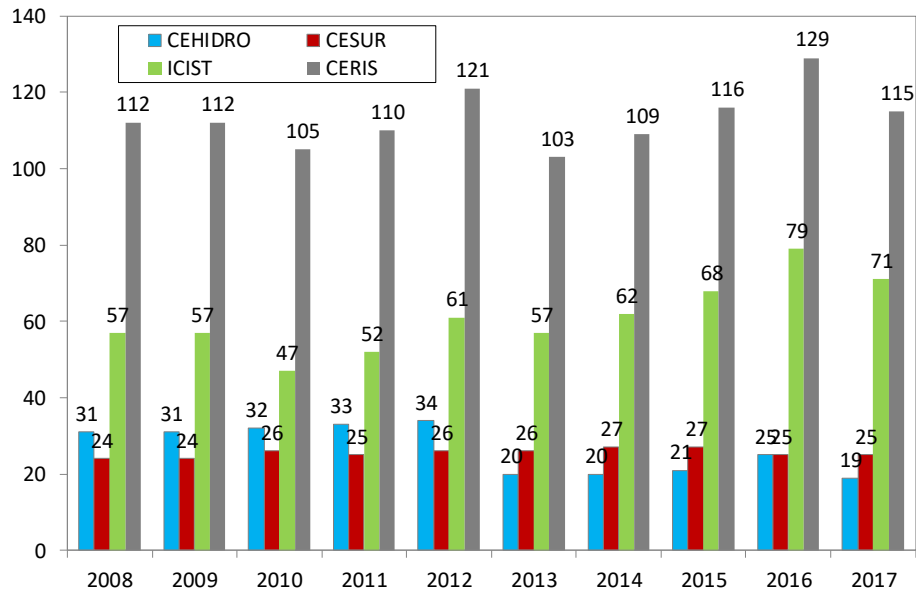
**Table 16 | 2017 activity indicators: other initiatives**

ACTIVITIES		CEHIDRO	CESUR	ICIST	CERIS
Models		1	0	0	1
Software applications		2	0	1	3
Pilot plants		3	0	1	4
Patents	National	0	0	1	1
	International	0	0	0	0

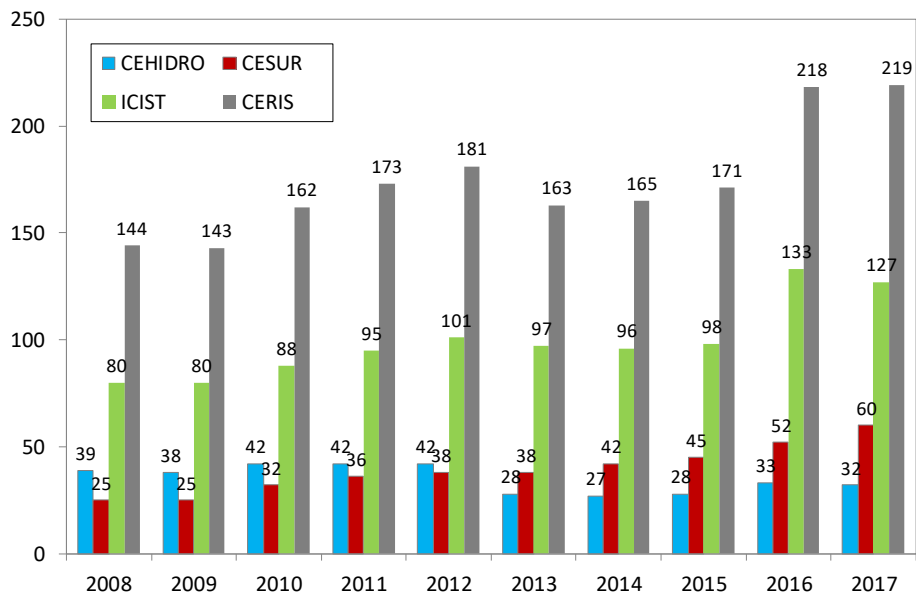
### 3.3 Evolution in the number of researchers

The evolution in the number of PhD members and PhD researchers is presented in Figure 2 and Figure 3, respectively. The number of PhD researchers is relatively stable since 2011. The variations are mainly

caused by changes in membership admission conditions, namely in ICIST in 2010 and in CEHIDRO in 2012. The increase in 2015 mainly reflects the integration in ICIST of academic staff of U. Nova de Lisboa, and the internal reclassification of PhD members and collaborators. The number of PhD researchers remained stable afterwards. However, an increase in the internal numerical criterion for selection of members in 2017 offset the increase of members that occurred in 2016.



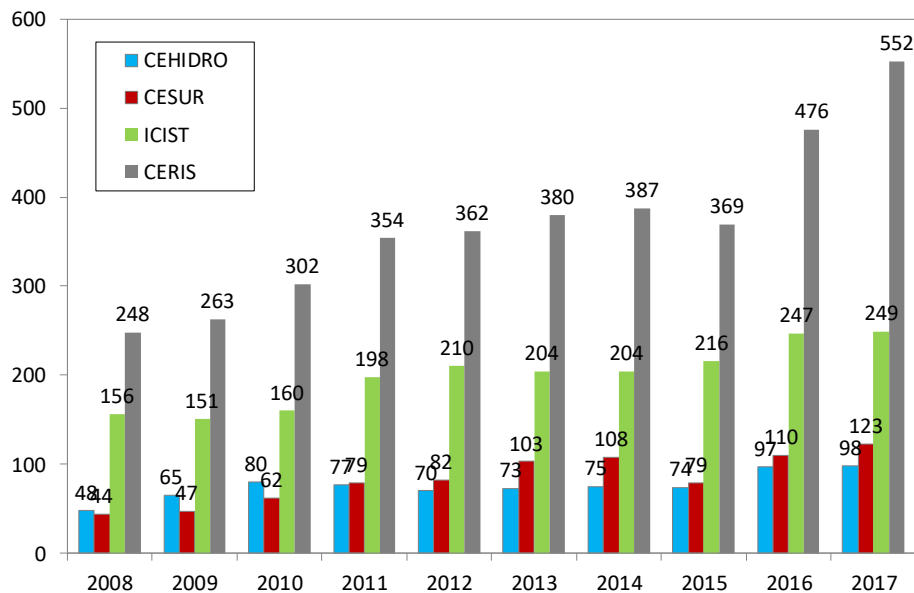
**Figure 2 | Evolution of PhD members**



**Figure 3 | Evolution of PhD researchers (PhD members and PhD collaborators)**

The evolution of the number of researchers - combining PhD members, PhD collaborators and PhD students and grant holders - is presented in Figure 4. The overall increase in the 2008-2011 period is mainly due to the expansion of the national program for doctoral grants. The ensuing economic crisis

justifies the subsequent stabilization. However, from 2016 onwards a quite significant increase occurred, which is explained by three main reasons: (i) the fulfilment of the last calls of the various FCT funded doctoral programmes, most of which led by CERIS; (ii) an increase of international PhD students, namely from Brazil; (iii) a more exact collection of the data concerning PhD supervision by CERIS researchers, namely of external students.



**Figure 4 | Evolution of the PhD members and collaborators and PhD students**

### 3.4 Evolution of research and consultancy funding

The aspects of the national economic scenario that are relevant in the present context are the following:

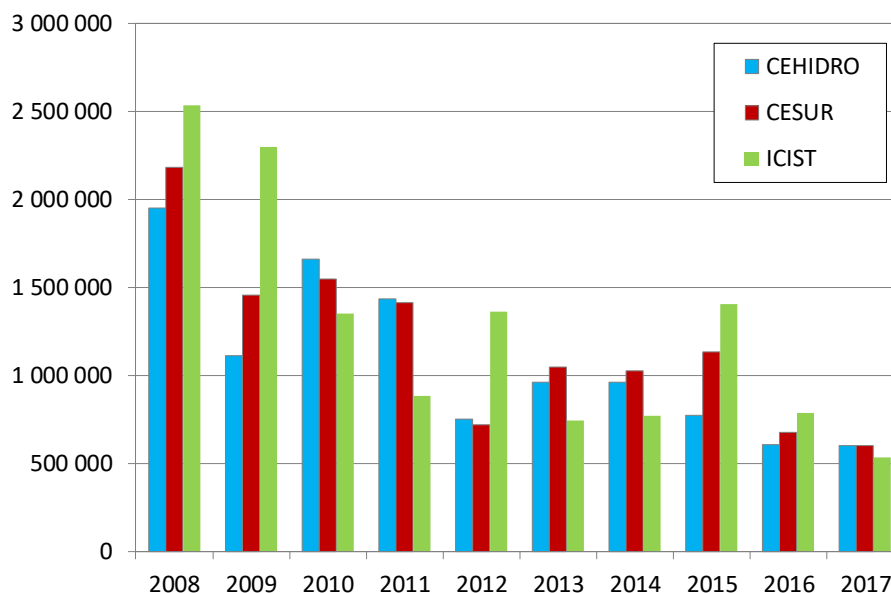
- (i) Austerity policies started to be implemented in 2010-2011 and induced an economic recession in 2013-2014 followed by a weak recovery after 2015;
- (ii) Public investment in RD&I, which had peaked in 2009, steadily decreased to the present day;
- (iii) Local and regional authorities and public agencies also suffered budget cuts in the same period;
- (iv) From 2007-2008 onwards, the largest contractors in the Civil Engineering sector invested in the internationalization of their activity, as the national infrastructure approached completion;
- (v) The economic crisis virtually paralyzed the Construction sector throughout this period, with a recent recovery based on the rehabilitation sector.

In the 2008-2012 evaluation period, the structure of the combined budget of the founding centres averaged 48% secured through research funding and 52% secured through consultancy funding. The latter form of funding combines all knowledge transfer activities, namely specialized consultancy and advanced on-going training. The decomposition of research funding was as follows: 21% allocated to the strategic program, the centre core funding yearly allocated by FCT; 52% secured through national competitions for research projects and research training programs (mostly promoted by FCT) and 27% through international competitions (mostly EU programs).

The numbers given above refer to a period when the effect of the economic crisis was already strong and were very much influenced by the results of the 2007 FCT evaluation of the research units (all founding centres of CERIS were ranked in the second best position at national level and first in the area of Civil Engineering). In fact, grading was directly linked to core funding, was valued in all FCT competitions for research funding and conferred the prestige essential to secure contracts with companies and public agencies. These policies remained active to the present day.

The results presented below for 2017 show how seriously CERIS was affected by the 2008-2012 evaluation (strategic funding), by the limitations imposed on the Lisbon region in P2020 calls in terms of research (national projects other than FCT funded), and by the economic crisis, in terms of consultancy: the budget decreased to 41% of the 2008-2012 average; consultancy funding fell 60% and the research funding fell to 43% of the 2008-2012 average. In 2017, 46% of the budget was sourced through research funding and 54% through consultancy funding.

The results presented in Figure 5, combining research and consultancy funds, reflect the increase in public research funding up to 2008 and the initial effects of the economic crisis on specialized consultancy. The following period is unstable, with tendency for a decreased capacity to secure both forms of funding. The peaks in 2010, 2012 and 2015 for CEHIDRO, ICIST and CESUR are circumstantial. For instance, in 2010 CEHIDRO signed a large contract to assist the Regional Government of Madeira Island in the aftermath of a major natural disaster. For all centres 2017 was the worst year in the last decade.

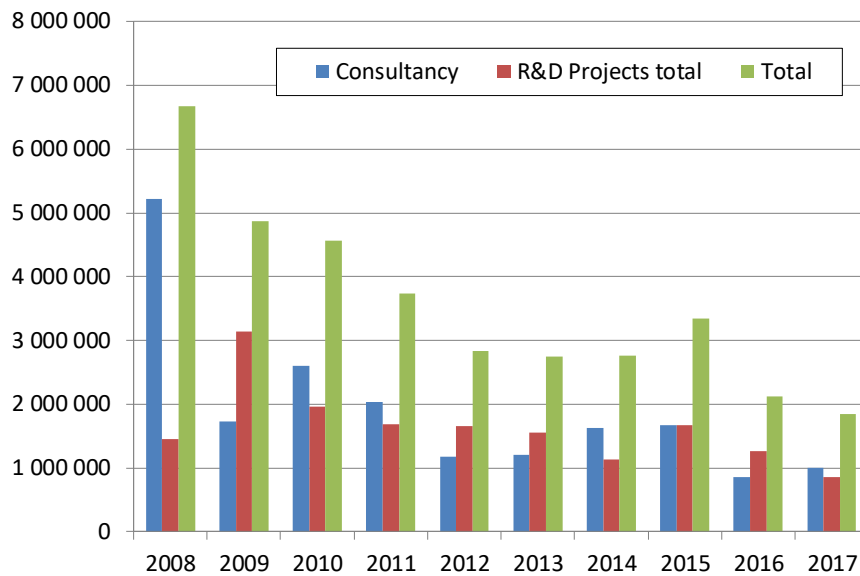


**Figure 5 | Total annual funding per research centre (research and consultancy)**

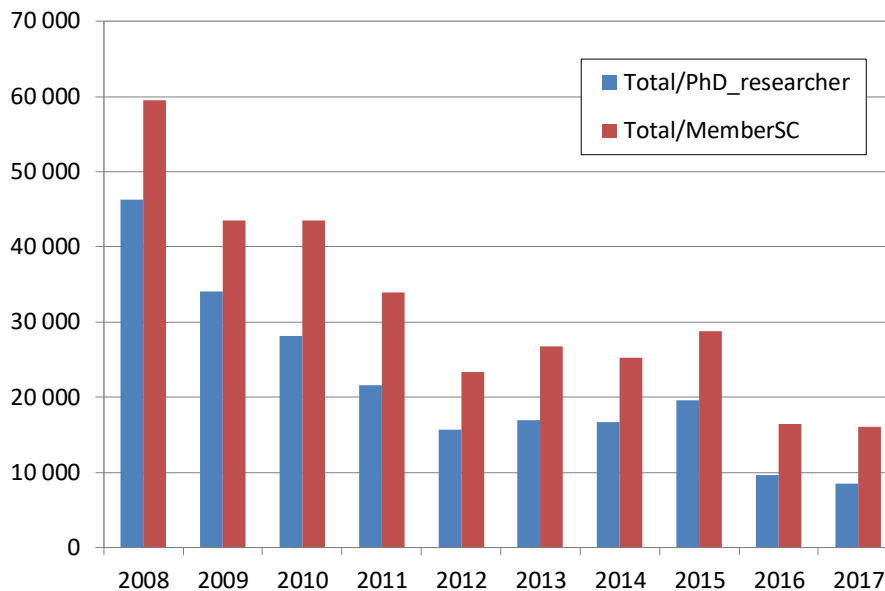
The combined funding in research and in consultancy is presented in Figure 6. The graph reflects the austerity measures taken throughout the 2010-2014 period. The results in 2014-2017 combine two effects: a stagnation of the economy (with an oscillation in 2015), the research funding losses caused by the last evaluation of CERIS and by the P2020 calls limitations for entities from the Lisbon region, and also by the irregularity of the disclosure of the results of applications to FCT funded projects. The total funding value

in 2017 (1.9 M€) is the worst in many years, with a significant loss in both consultancy and a research funding relative to previous period.

As the number of PhD researchers (combining PhD members and PhD collaborators) did not substantially change in the period under analysis, a similar pattern is found in Figure 7, which illustrates the evolution of the capacity of PhD members to secure either forms of funding. In 2017, the average total funding was 8.5 k€ per PhD researcher and 16.1 k€ per PhD member. The capacity of members to secure funding used to support research activities decreased to 27% of the 2008 peak values.



**Figure 6 | Annual funding in research and in consultancy**



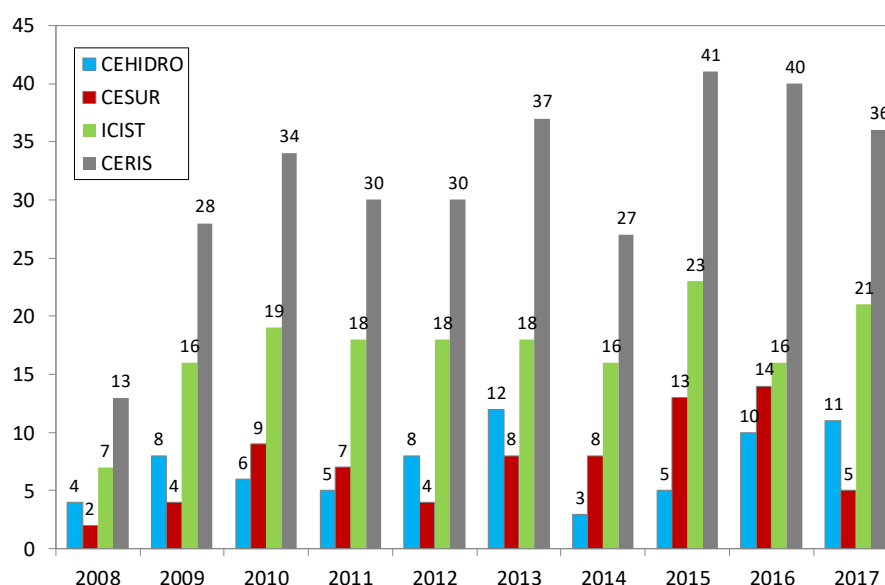
**Figure 7 | Total annual funding per PhD researcher and per PhD member**

The impact of the national economic crisis illustrated above coincides in 2017 (and 2016) with the first direct consequences of the 2008-2012 evaluation of CERIS. As a result of its current grading, core funding in 2017 was around 65% of the average registered in that period.

Moreover, the capacity of CERIS to secure research funding decreased in 2014-2017. Nevertheless, Table 15 shows a relatively high success rate in competitive research projects and grants (especially at an international level, where members have been very active in submitting proposals), apparently contradicting the fall registered in the national success rates substantially caused by the cuts introduced in public funding of research. However, in terms of national grants, this was again an uncharacteristic year, because no FCT projects were awarded following the 2017 call (results are still to be released).

### 3.5 Evolution of the main activity indicators

The evolution of the number of completed PhD theses is shown in Figure 8. The oscillations are associated with differences in completion caused by PhD programs with dissimilar requirements in mandatory courses and, consequently, in breadth and depth of the research project. They are also affected by the cuts in the national program for PhD grants, which were attenuated by the engagement of CERIS in independently funded international bilateral consortia (namely through the Portugal-MIT and Portugal-U. Texas Programs) and FCT-funded PhD programs. The first editions of most of these programs will be completed in 2018, which allows envisaging an increase in this indicator in the upcoming years.



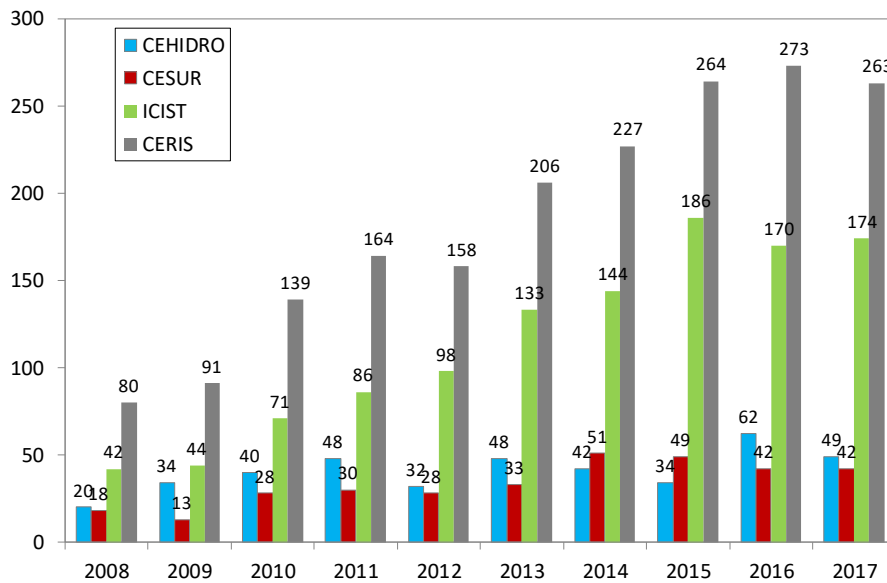
**Figure 8 | Concluded PhD theses**

In 2017, and as mentioned in Section 2.6, the ratio of PhD students (including CERIS and external students) to PhD members entered or exceeded the target range in all centres: CEHIDRO (4.5, well above the target), CESUR (3.3) and ICIST (2.4).

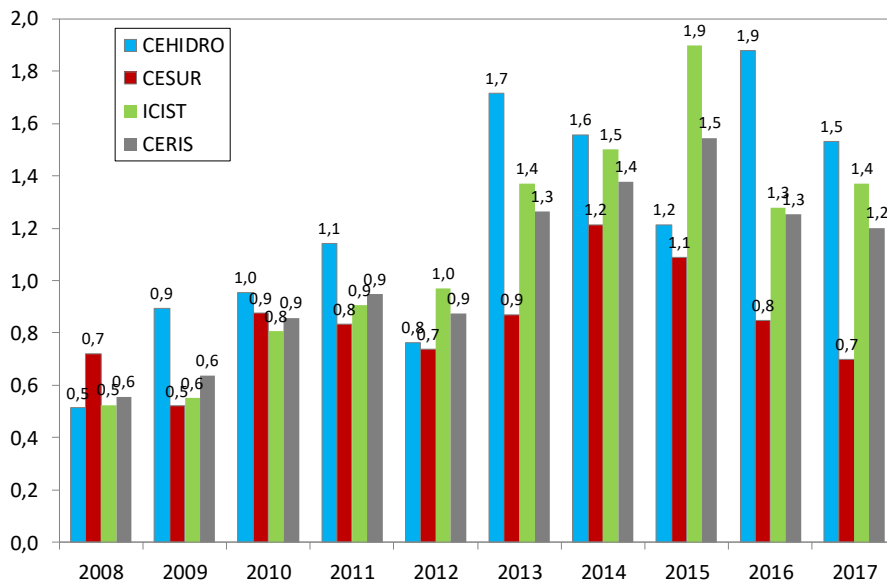
The success in securing PhD contracts under FCT-funded doctoral programs is one of the key reasons why CERIS kept improving the main activity indicators under otherwise adverse conditions. CERIS succeeded in coordinating five and participating in another PhD program selected for funding in an internationally evaluated national competition held by FCT. No remotely similar rate of success was registered in the area of Engineering.

The evolution of the total number of papers published by CERIS researchers is presented in Figure 9. The oscillations are related with the size of the smaller research centres, CEHIDRO and CESUR, and the overall tendency is determined by the largest centre, ICIST. The graph shows a consistent increase in the scientific activity from 2008, with the exception of 2012 (possibly caused by a previous decrease in the number of concluded PhD theses), and a stabilization plateau in 2015-17.

The publication ratios per PhD researcher and per PhD member are presented in Figure 10 and Figure 11, respectively, respectively.

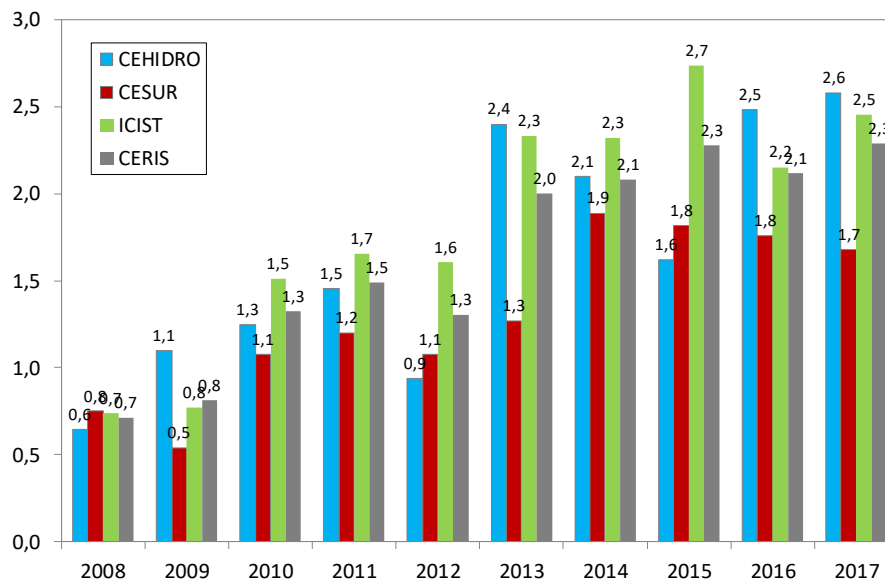


**Figure 9 | Papers published in international journals (ISI and Scopus)**



**Figure 10 | Publication in ISI/Scopus journals per PhD researcher**



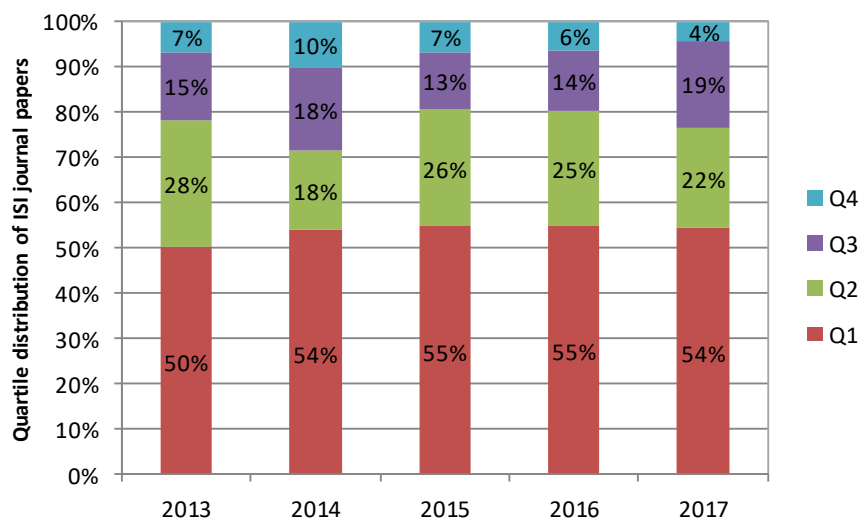


**Figure 11 | Publication in ISI/Scopus journals per PhD member**

The 2017 ratios were 1.2 papers per PhD researcher and 2.3 per PhD member. The patterns are similar (although more variable) for publications in conference proceedings, with 2017 ratios per PhD member of 2.7 and 0.6 for international and national conferences, respectively. It is recalled that CERIS combines a very diverse community of researchers with quite different cultures of reporting research results. For instance, journal publishing is not valued similarly in the areas of Architecture and Urbanism.

As mentioned in Section 2.6, the number and the distribution of PhD students is not directly related with publication ratios. ICIST has the lowest ratio in PhD students per PhD member and the highest ratio in publications in ISI/Scopus journals. Both ratios can substantially vary at the group level. It is also noted that publication in Scopus journals is marginal (in 2017, 2% of the total, as shown in Table 13).

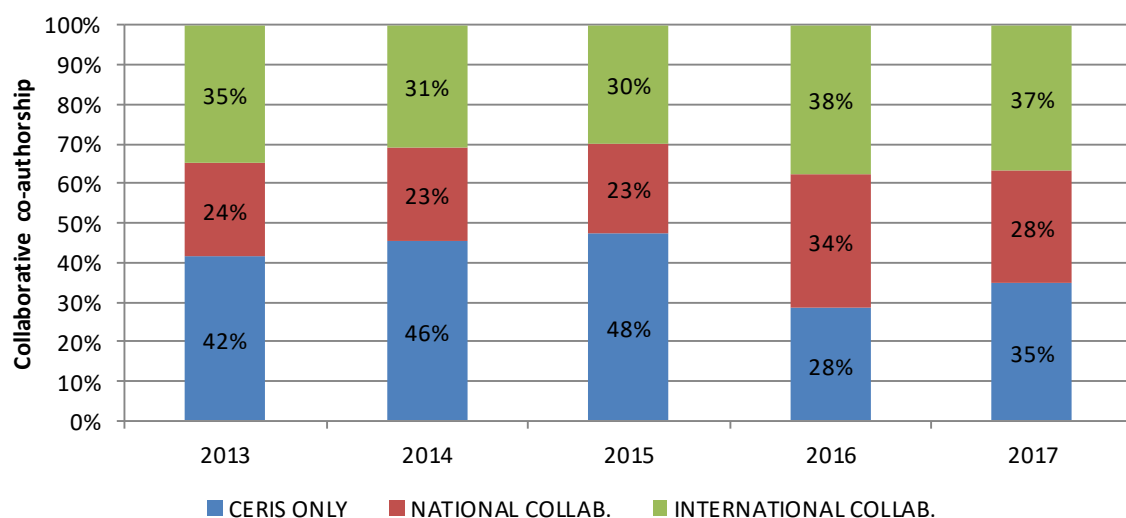
Figure 12 depicts the distribution of the papers published in ISI journals per quartile of impact factor.



**Figure 12 | Distribution of papers published in ISI journals per quartile (Q1 to Q4) of impact factor**

In the 2013-2017 period, more than 50% of the papers were published in Q1 journals. This number was relatively stable during this period, with a stabilization trend after 2014. In 2017 this figure was 54%; moreover, 76% of the papers were published in Q1 and Q2 journals, attesting the relatively high average quality of the journal publications of CERIS members.

Figure 13 shows the distribution of the papers published in ISI/Scopus journals according to the collaboration in terms of co-authorship: (i) only CERIS co-authors; (ii) co-authors from other national institutions; (iii) co-authors from international institutions. The numbers fluctuate over the years, but there is a general increasing trend of both types of collaborations, especially after 2015, with about 65% of publications resulting from effective external collaborations.



**Figure 14 | Distribution of papers published in ISI journals per quartile (Q1 to Q4) of impact factor**

### 3.6 Research group results

The contribution of the research groups to the activity indicators presented above is summarized next. As in Section 2.4, the information distinguishes CERIS PhD students (registered with IST-UL) from external PhD students (registered with other universities and co-supervised by CERIS members). Moreover, the PhD students are assigned to the groups of their supervisors and co-supervisors (in the CERIS overall figures repetitions resulting from this criterion have been eliminated).

#### RG1a | Architecture

##### 6 PhD members | 10 PhD collaborators | 35/8 PhD students (CERIS-IST/External)

- 5 (37) PhD theses successfully completed (in progress);
- 36 (31) MSc theses successfully completed (in progress);
- 7 (1) papers in ISI (Scopus) journals, 16 (0) communications in international (national) conferences proceedings, 1 entire book, 4 book chapters and 3 book editions;
- 3 technical-scientific reports resulting from 4 (3) international (national) projects in progress;
- 2 (0) international (national) project grants awarded and 4 (4) other international (national)

- research grants submitted;
- 5 (0) participations in the editorial boards of international (national) journals;
- 16 collaborations in reviewing papers submitted to international journals<sup>2</sup>;
- Participation in the scientific committees of 14 (1) international (national) conferences;
- Participation in 2 international committees responsible for drafting design codes or recommendations;
- Organization of 6 (3) international (national) conferences;
- 4 participations as referees for funding agencies (national and international).

### **RG1b | Urbanism**

#### **6 PhD members | 9 PhD collaborators | 7/6 PhD students (CERIS-IST/External)**

- 1 (12) PhD theses successfully completed (in progress);
- 27 (35) MSc theses successfully completed (in progress);
- 5 (0) papers in ISI (Scopus) journals, 8 (1) communications in international (national) conferences proceedings, and 3 book chapters authored;
- 17 reports related to consultancy projects and industry contract research projects;
- 3 technical-scientific reports resulting from 1 (1) international (national) projects in progress;
- 3 (1) participations in the editorial boards of international (national) journals;
- 20 (4) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 4 international conferences;
- Organization of 2 (0) international (national) conferences.

### **RG2 | Hydraulics**

#### **7 PhD members | 9 PhD collaborators | 33/7 PhD students (CERIS-IST/External)**

- 5 (35) PhD theses successfully completed (in progress);
- 19 (23) MSc theses successfully completed (in progress);
- 31 (0) papers in ISI (Scopus) journals and 32 (17) communications in international (national) conferences proceedings;
- 3 reports related to consultancy projects and industry contract research projects;
- 3 technical-scientific reports resulting from 4 (8) international (national) projects in progress;
- 2 (1) international (national) project grants awarded and 2 (12) other international (national) research grants submitted;
- 7 (1) individual grants awarded (submitted);
- 8 (2) participations in the editorial boards of international (national) journals;

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<sup>2</sup> A collaboration is here understood as at least one review by any individual CERIS researcher for a journal (two reviews by different researchers for the same journal are considered two collaborations; several reviews by the same researcher to the same journal are considered one collaboration).

- 56 (1) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 10 (4) international (national) conferences;
- Organization of 4 international conferences.

### **RG3 | Environment and Water Resources**

#### **12 PhD members | 4 PhD collaborators | 33/12 PhD students (CERIS-IST/External)**

- 6 (39) PhD theses successfully completed (in progress);
- 31 (16) MSc theses successfully completed (in progress);
- 18 (0) papers in ISI (Scopus) journals, 53 (13) communications in international (national) conferences proceedings, 1 entire book and 3 book chapters authored;
- 13 reports related to consultancy projects and industry contract research projects;
- 3 technical-scientific reports from 1 international project in progress;
- 1 (1) international (national) research grants awarded and 9 (6) international (national) research grants submitted;
- 4 (0) individual grants awarded (submitted);
- 10 (8) participations in the editorial boards of international (national) journals;
- 76 (7) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 14 (16) international (national) conferences;
- Participation in 5 (4) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 4 (0) international (national) conferences;
- 7 participations as referee for funding agencies (national and international).

### **RG4 | Systems and Management**

#### **8 PhD members | 14 PhD collaborators | 27/5 PhD students (CERIS-IST/External)**

- 1 (31) PhD theses completed (in progress);
- 23 (49) MSc theses successfully completed (in progress);
- 21 (0) papers in ISI (Scopus) journals, 21 (1) communications in international (national) conferences proceedings, 2 entire books and 6 book chapters authored;
- 5 reports related to consultancy projects and industry contract research projects;
- 3 (2) international (national) project grants awarded and 9 (9) other international (national) research grants submitted;
- 1 (2) individual grant awarded (submitted);
- 7 participation in the editorial boards of international journals;
- 75 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 14 (0) international (national) conferences;
- Participation in 2 (1) international (national) committees responsible for drafting design codes or recommendations;

- Organization of 4 (3) international (national) conferences;
- 1 international award.

### **RG5 | Transportation Systems**

#### **11 PhD members | 12 PhD collaborators | 33/9 PhD students (CERIS-IST/External)**

- 3 (40) PhD theses successfully completed (in progress);
- 33 (25) MSc theses successfully completed (in progress);
- 19 (0) papers in ISI (Scopus) journals, 48 (6) communications in international (national) conferences proceedings and 1 book chapter authored;
- 6 reports related to consultancy projects and industry contract research projects;
- 1 technical-scientific report from 4 international projects in progress;
- 3 national project grants submitted;
- 9 participations in the editorial boards of international journals;
- 31 (1) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 17 (1) international (national) conferences;
- Organization of 6 (2) international (national) conferences;
- 2 national awards.

### **RG6 | Studies on Construction**

#### **28 PhD members | 13 PhD collaborators | 51/21 PhD students (CERIS-IST/External)**

- 5 (65) PhD theses successfully completed (in progress);
- 86 (81) MSc theses successfully completed (in progress);
- 88 (1) papers in ISI (Scopus) journals, 54 (19) communications in international (national) conferences proceedings, 1 entire book and 5 book chapters authored;
- 32 reports related to consultancy projects and industry contract research projects;
- 15 technical-scientific reports resulting from 7 (14) international (national) projects in progress;
- 2 (1) international (national) project grants awarded and 9 (27) other international (national) research grants submitted;
- 12 (7) individual grants awarded (submitted);
- 40 (8) participations in the editorial boards of international (national) journals;
- 423 (17) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 40 (9) international (national) conferences;
- Participation in 20 (31) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 2 (4) international (national) conferences;
- 10 participations as referees for funding agencies (national and international);
- 5 national and international awards.



## **RG7 | Structures and Geotechnics**

### **37 PhD members | 33 PhD collaborators | 45/22 PhD students (CERIS-IST/External)**

- 13 (55) PhD theses successfully completed (in progress);
- 98 (70) MSc theses successfully completed (in progress);
- 87 (1) papers in ISI (Scopus) journals, 76 (11) communications in international (national) conferences proceedings, 1 entire book and 4 book chapters authored, and 1 book edition;
- 9 reports related to consultancy projects and industry contract research projects;
- 1 technical-scientific reports resulting from 3 (15) international (national) projects in progress;
- 1 (0) international (national) project grant awarded and 1 (11) other international (national) research grants submitted;
- 10 (0) individual grants awarded (submitted);
- 44 (20) participations in the editorial boards of international (national) journals;
- 173 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 31 (29) international (national) conferences;
- Participation in 49 (34) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 15 (11) international (national) conferences;
- 17 participations as referees for funding agencies (national and international);
- 4 national and international awards.

## 4. FUTURE RESEARCH

The CERIS activities planned for 2018 are a natural follow-up of the research carried out in 2017, as summarized in Section 0. The proposed activity, as submitted by the coordinators of the research groups, will benefit from the internal program to promote cooperation in research, as framed by the thematic strands and the work areas presented in Sections 0 and 0.

The profiles of the research groups given below refer to 2017. They will change in 2019 in consequence of the CiTUA application as a new research unit (Table 11) and adjustments in the number of PhD students. It is reasonable to expect that the students that successfully completed their degrees in 2017 will be replaced by a similar number of doctoral students and that some will remain in CERIS as PhD collaborators.

### **RG1a | Architecture**

#### **6 PhD members | 10 PhD collaborators | 35/8 PhD students (CERIS-IST/External)**

The 2018 research is planned in the scope of two thematic strands: Product Development (TS1) and Rehabilitation of Natural and Built Environments (TS3). It is focused on conservative, re-use and transformative approaches to the rehabilitation of the built environment including product development in order to meet new societal demands and sustainability targets within a user-centred approach. Research activities are organized according to four research domains as follows:

#### a) Reuse of architectural heritage

- Comprehensive analysis and inventories of the built fabric based on surveys and documentary resources;
- Documentation and research of built space transformation processes and the relationship between heritage and development strategies;
- Analysis of architectural typologies and building systems to respond to current building regulations and standards;
- Identification of social-cultural-economic impacts of the adaptive re-use of buildings and sites.

#### b) Space-use analysis (characterization/diagnosis/assessment/proposal)

- Comprehensive study of educational architecture in Portugal;
- Development of self-assessment tools to be applied along the building process (programming, design and occupancy phases) including automatic systems to monitor and log use data in buildings and public spaces (Space-Use platform);
- Development of models of form and function to interpret the social, technical and economic significance and implications of built environment (post occupancy evaluations).

#### c) Adaptive processes

- Innovation and integration in the planning process and architecture through the use of new integrated technologies, 3D modelling for computer / 4D structures to establish links between CAD and CAM technologies;

- Development of parametric modelling systems and processes;
- Development of new architectural design processes and approaches based on low-cost modular solutions;
- Development of integrative architectural design solutions with low embodied energy and optimize energy consumption and comfort performance through the integration of bioclimatic strategies in planning and design stage.

d) Architectural design methods and processes

- Comprehensive analysis of the impacts of digital representation systems and BIM models;
- Development of collaborative platforms for 3D Modelling and Visualising and design protocols, (reasoning, problem solving, and communication).

**RG1b | Urbanism**

**6 PhD members | 9 PhD collaborators | 7/6 PhD students (CERIS-IST/External)**

The research carried out in 2017 targeting the thematic strands on Risk and Safety (TS2), Rehabilitation (TS3) and Response to changes (TS4) will be extended in 2018. The FCT funded PSSS project is underway. Not previously funded research proposals will be re-evaluated, updated and improved and new funding opportunities will be searched for. New proposals under the global objectives will also be developed. Networking with PLPR (The International Academic Association on Planning, Law, and Property Rights) will be reinforced.

Two books to disseminate results of two recently concluded projects (PERCOM and PERIURBAN) will be edited. A new project will be launched focused on health aspects in urban planning and on ICT-Enhanced Smart Inclusive and Safe Mobility. This will be achieved in the scope of on-going PhD and Master Theses who are involved and engaged in the research activities of the group and will participate in publications. Furthermore, a working group will reflect on planning systems using an international comparative approach taking advantage of the AESOP framework.

**RG2 | Hydraulics**

**7 PhD members | 9 PhD collaborators | 33/7 PhD students (CERIS-IST/External)**

The programmed research for 2018 is organized in the following major topics of thematic strands TS2 (Risk and Safety) and TS3 (Rehabilitation):

a) Pressurized water systems

- Methodologies and software tools for assessment and enhancement of water-use and energy efficiency in water supply systems;
- Development of reliability analyses and risk management tools for different types of water and wastewater infrastructures;
- Safety, risk analyses and design criteria for pressurized pipe systems.



b) Fluvial hydraulic structures

- Analysis and enhancement of different flood release and related hydraulic structures;
- Energy dissipation downstream of stepped spillways and in plunge pool spillways;
- Techniques for the suppression of driftwood in slit dams.

c) River restoration and management

- Monitoring tools, based on physically-based computational models, for water and sediment quality in rivers and estuaries;
- Risk management in the valleys downstream of dams;
- Spawning areas identification and development of shelters for fish downstream of powerhouses with hydropeaking operation;
- Ecohydraulic thresholds for vertical slot fishpass design for cyprinids;
- Environmental flows determination procedures and hydropower station operation rules to reduce ecological risk downstream of dams.

d) Environmental fluid mechanics

- Investigation of rough-wall open-channel turbulence;
- CFD simulation of solid-fluid interactions in turbulent flows;
- Transport processes of dissolved substances.

e) Sediment transport and river morphodynamics

- Analysis of scour at single and complex bridge piers and development of scour countermeasures for bridge foundations;
- Elaboration of guidelines for the rehabilitation of river confluences;
- Mathematical modelling of shallow-flows with mobile beds. Application to long term channel morphology evolution, dam-breaching, dam-break flows and overland tsunami propagation;
- Development of stabilization techniques for rivers meanders in equilibrium.

f) Ocean waves and coastal and port structures

- Inundation of estuarine cities by storm surges and river flows;
- Life-cycle cost analysis of coastal and port structures;
- Turbulent transport processes in rivers and estuaries: interaction between transported quantities (sediment, pollutants, nutrients, etc.) and turbulence.

**RG3 | Environment and Water Resources**

**12 PhD members | 4 PhD collaborators | 33/12 PhD students (CERIS-IST/External)**

RG3 will continue to focus the research on the areas of environment, water resources ( surface and groundwater) and water services, specially addressed in thematic strands TS2 (Risk and Safety), TS3 (Rehabilitation) and TS4 (Response to Societal Changes), with the objective of developing approaches, methodologies and tools that cut across these areas, improving knowledge and capabilities, and bridging the gap between theory and experimentation, using the results and experience of its members to support

the management of natural and built environments in a sustainable way, and increase the productivity indicators of the group and the impact of the internationalisation activities of its members.

RG3 will concentrate its activities in the following major areas:

- Water policy and governance;
- Environmental management of natural and built environments;
- Impact assessment;
- Monitoring and modelling of hydrologic processes;
- Flood and drought risk assessment studies;
- Integrated water resources management;
- Managing water, food and energy nexus and adaptation of structures and systems to cope with climate change;
- Strategic investment planning on water services;
- Sanitation techniques and approaches and the Sustainable Development Goals;
- Monitoring and mathematical simulation of wastewater systems including of nature based solutions;
- Assessing and managing resilience in urban water systems;
- Aquifer recharge evaluation;
- Groundwater pollution and risk assessment;
- Groundwater, ecosystems and bio-indicators;
- Monitoring and aquifer testing;
- Groundwater and global change;
- Urban hydrogeology;
- Geophysics applied to hydrogeology;
- Numerical and stochastic groundwater modelling;
- SSD applied to groundwater management;
- Life cycle assessment of soil and groundwater remediation and health risks.

#### **RG4 | Systems and Management**

**8 PhD members | 14 PhD collaborators | 27/5 PhD students (CERIS-IST/External)**

In line with the activity developed in the previous period, the planned research activities of the group will have the following drivers:

- a) To attract and stimulate young researchers to pursue advanced studies and to develop innovative ideas;
- b) To contribute to the introduction and dissemination of innovation and best practices in organizations;
- c) To internationalize the group allowing the participation in cross-countries studies and the mobility among researchers.

These drivers will be pushed within 4 major knowledge areas and the following future developments:

**Project Management, Procurement and Contracting:** The Group is focused on improvement the processes and infrastructure projects through the development of better models for project management and the procurement of goods, services and works. In the coming years new solutions will be proposed to achieve higher levels of efficiency and effectiveness, particularly in the scope of public-private partnerships arrangements.

**Decision-making and Systems Design, Operations and Management:** The Group is focused on the study of risk in any natural or built environment requires modelling complex systems, namely urban networks, designed to guarantee the fulfilment of societal needs expressed in terms of information, energy, water, mobility and supplies of a wide spectrum of goods and services. In the coming years the group will pursue the development of advanced tools to design and to optimize such complex systems, increasing safety and resilience.

**Regulatory Policies, Pricing and Performance Assessment:** The Group is focused on open and comprehensive search for understanding new societal problems. Many of these challenges are directly related to the performance of complex organizations serving communities and cities. In the coming years, the group will promote the development of: a) models of complex organizations providing public goods or services, such as water supply, waste schooling, logistics and health networks; b) regulatory frameworks and adaptive approaches to propose better pricing and performance evaluation systems, allowing for benchmarking and rankings, particularly in infrastructure and other public services.

**Information Modelling and Technologies.** The Group is particularly concerned with the area of Geomatics and Geographical Information Science, Project Management and Information Support Systems and Information Technologies. In the coming years, the area of Geomatics and Geographical Information Science will focus the research on ground deformation measure with advanced SAR interferometric methods and 3D CIM models and its application and spatial analysis problems. In the area of Project Management and Information Support Systems and Information Technologies, the principal research topics will be focused on Building information modelling and systems interoperability; BIM standardization; Innovation management; Information management; Business process management; Collaborative systems, e-business and e-procurement.

The research development strategy will be based on three fundamental pillars:

- a) Existing skills and capacities to capture the essence of each problem and to devise appropriate frameworks that fit the decision context;
- b) Societal and industrial relevance of the issues to be addressed and capability to attract and engage partners that provide case-studies and funding;
- c) Internationalization and networking of their members and ability to attract young researchers and involvement in international project teams.

The S&M group has a long tradition of engagement in applied research and innovative services provision for private and public organizations and we intend to reinforce these industrial links. It is also our objective to consolidate our reputation as one of the leading groups in the areas of Operational Research &



Engineering Systems in Portugal and abroad in particular areas, aiming at strengthening our international collaborative ties and recognition. Providing contributions for the literature and increasing the number of published papers in leading international journals, in parallel with active participation in international forums and projects, is also a means to promote international visibility and recognition.

### **RG5 | Transportation Systems**

**11 PhD members | 12 PhD collaborators | 33/9 PhD students (CERIS-IST/External)**

RG5 addresses topics that cut across all thematic strands, in the context described by the research topics listed in Section 2.4, as well as new ones arising from the spotted needs and opportunities. The activity in 2018 intends to:

- Renew and reinforce the commitment to reach internationally recognized scientific excellence;
- Answer society's needs for national and international transport and infrastructure systems;
- Set up a wide social base of stakeholders for contract research and advanced training;
- Develop and sustain collaboration and continue to participate in national and international professional and academic networks and thus increase the formal support of R&I&D and its visibility and effectiveness;
- Enhance the international PhD program (in association with MIT, UC and UP) and its recognition on a very broad international level, as well as all the other professional training initiatives with industry in order to spot R&I&D opportunities that reinforce the group growth in this field.

This activity will be pursued using the means and the routes offered by EU (Horizon 2020) and nationally (Portugal 2020) financed research projects, by the research involved in each on-going PhD works integrated on the doctoral program in Transportation Systems, by the innovation, the technology and the development transfer to society and industry, by supporting the training professional programs set with several stakeholders on the transportation and infrastructure systems, and by the improvement of the results achieved within the international networks already established and the ones to enhance if the opportunity comes.

### **RG6 | Studies on Construction**

**28 PhD members | 13 PhD collaborators | 51/21 PhD students (CERIS-IST/External)**

The general objectives of the group for 2018 are to develop research projects in the domains of Construction Materials, Technology and Management Innovation; Sustainable Construction; Monitoring, Rehabilitation and Conservation of the Built Heritage, addressed in thematic strands TS1 (Product Development) and TS3 (Rehabilitation). An effort will be made to concentrate efforts in increasingly less wide and more specific fields to produce relevant results as measured by the main scientific productivity indicators. The major topics and activities planned for 2018 are:

- Advanced materials and technologies also focusing on nanomaterials - establish international cooperation and be a national leader in the field of composites (CFRP and GFRP);

- Concrete and mortars technology - proceed with PhD and MSc studies under way (in strong collaboration with LNEC) and improve the Mortars Section of the Construction Laboratory;
- Construction quality, safety, environmental and health management - increase the international cooperation via technical committees and international conferences;
- Sustainability and deconstruction strategies and technology - proceed with PhD and MSc studies under way and be a national and international reference in the field of recycled aggregates for concrete and mortars production and other eco-materials;
- Building physics and passive design maintain the results in the near past and expand its potential through studies on energy efficiency and acoustics of innovative materials, components and construction systems;
- Energy Performance of Buildings - continue collaboration with the Mechanical Engineering and Physics Departments of IST in terms of inspection, diagnosis, maintenance and rehabilitation systems - proceed with PhD and MSc studies under way and be a national and international reference in the field of inspection and diagnosis systems;;
- Conservation of historical building heritage - continue and strengthen national and international cooperation projects, namely within the Construction Technological Portuguese Platform (PTPC).

The group will continue its strong integration in the FCT Doctoral Program EcoCoRe (Eco-Construction and Rehabilitation), headed from its beginning by a member of the group.

### **RG7 | Structures and Geotechnics**

**37 PhD members | 33 PhD collaborators | 45/22 PhD students (CERIS-IST/External)**

The research activity planned for 2018 comprises the following topics and actions:

#### a) Finite element modelling of nonlinear structural behaviour

- Development, validation, automation and dissemination of geometrically/physically nonlinear GBT formulations for buckling, vibration and dynamic analyses of thin-walled members and structural systems (continuous beams, 2D and 3D trusses and frames);
- Structural response and DSM design of cold-formed steel thin-walled members, with different cross-sections, loading and support conditions, undergoing mode interaction phenomena involving local, distortional and global deformations.
- Simulation of mechanisms inducing degeneration of biphasic soft tissues in hip joints with femoroacetabular impingement;
- Coupled experimental-numerical optimization, interpretation and standardization of bender element testing of triphasic geomaterials using hybrid FE formulations;
- Transient, nonlinear hygro-chemo-thermo-mechanical models for high-strength concrete and GFRP reinforcement, based using enhanced/hybrid FE formulations;
- Consistent, geometrically exact formulations for beams, including cross-section deformations, and thin and thick shells based on a meshless formulation.

b) Earthquake Engineering and Seismology

- Coordinate and develop the European Project “KnowRisk”;
- Analyse the feasibility of introducing seismic early-warning in Portugal through improvements in the Portuguese National Strong Motion Network;
- Promote and develop information/learning materials as well as communication/awareness actions about seismic risk to the population, to facilitate and assure a better prevention and preparedness;
- Advance the studies on the field of structural reinforcement of masonry structures, including solutions for old building walls involving viscous dampers, shape memory alloys and steel hysteretic dampers;
- Proceed with the studies on displacement based methods for the assessment of the seismic vulnerability of existing reinforced concrete buildings;
- Proceed the research on the seismic vulnerability of footbridges and assessment of rehabilitation solutions using shape memory alloys connectors;
- Advance the cooperation with CINAMIL to develop performing strengthening solutions for structural elements subjected to blast loads;
- Continue the research in the field of modular constructions especially on energy sustainability details in the previously developed modular system.

c) Structural Concrete

- Continue the research in advanced cementitious materials, with particular emphasis on innovative solutions combining ultra-high durability with eco-efficiency
- Proceed with novel developments in both deterioration predictive models and preventive / remedial procedures
- Proceed with novel developments in both design models (e.g. stress-fields models) and structural modelling (e.g. FEM-based software with embedded strong discontinuities),
- Deepen the studies on the assessment of existing structures (e.g. reliability, structural robustness, monitoring, seismic vulnerability),
- Continue the studies on rehabilitation (e.g. repairing and strengthening techniques, seismic strengthening, passive protection),
- Increase the focus on new products for the prefabrication industry.

d) Steel and Composite Structures

- Studies on steel sub assemblages with bolted and welded dissipative fuses;
- Development of numerical models to simulate the behaviour of structural members and parts;
- Proposal of design rules for steel and composite structural members and parts;
- Applications to steel and composite bridges.

e) Bridge and Special Structures

- Design of steel-concrete composite bridge decks using high strength steel.
- Higher order beam models. Analysis of curved bridge girders and steel-concrete bridge girders; analysis of structures with generic cross-sections considering the displacement field approximated over the cross-section by meshes of two dimensional domains.

- Dynamic analysis of bridges. Response to moving loads; influence of in-plane cross-section deformation. Application of higher order beam models.
- Geometrical and physical non-linear analysis of steel thin-walled structures: Buckling of curved steel plate girder panels with longitudinal stiffeners; Buckling resistance of steel plate girders considering M-V interaction with high compression forces; Stiffeners design for steel and steel-concrete composite bridge decks. Application of higher order beam models.
- Analysis and design of offshore structures.

f) Geotechnics

- Three-phase modelling of unsaturated structural foundation media;
- Chemo-mechanical modelling of biological porous media;
- Modelling of friction in dynamic structural instability;
- Non-smooth dynamic analysis of passive energy dissipation systems;
- Beams on a foundation under moving vehicles.

## 5. CLOSURE

CERIS merged in 2015 three research centres of DECivil, namely CEHIDRO (Centre of Hydraulics, Water Resources and Environment), CESUR (Centre for Urban and Regional Systems) and ICIST (Institute of Structural Engineering, Territory and Construction).

Their integration in CERIS was designed to exploit a comprehensive thematic coverage, in depth and scope, promoting synergies in the multidisciplinary sector of Built and Natural Environment. Indeed, CERIS was created to address the main issues identified in key documents on the prospects of the sector and to respond thus to recommendations to enhance strengths and to overcome weaknesses identified by the external advisory boards and the international evaluation panels of its founding centres when they operated independently.

In 2017, CERIS joined the expertise of 219 PhD researchers and 333 PhD students (244 enrolled at IST), having the profile and the critical mass needed to sustain a leading national position and to attain a strong international presence in the sector. The feasibility of these central objectives was confirmed in the first three years of formal operation of CERIS, which also confirmed the need to face the challenges and solve the difficulties foreseen in the discussions that led to its creation.

CERIS is classified by FCT as the only 'large research unit' in the area of Civil Engineering. In terms of day-to-day operation, one set of difficulties relates to inherited weaknesses in technical staff in what regards the operation of laboratories and, especially, the creation of an administrative structure competent in the management of Science and Technology. As the merging of the centres must yield an improved use of human resources, CERIS should use its own resources to engage and train the necessary technical staff in preparation of the announced waiving of the current freeze on recruiting.

A second set of foreseen difficulties concern the need of agreeing to and implementing common regulations, rules and criteria in long-established centres with different cultures and practices. This challenge was successfully met, creating the conditions to implement strategic and operational objectives guiding the development of CERIS. Standardization of internal procedures was also addressed in 2016 and further developments have shown that they were well accomplished.

The discussion that led to the creation of CERIS was mainly focused on the dual challenge of respecting the identity of the founding centres while actively promoting internal cooperation in a new unit rich in synergies in the main areas of Built and Natural Environment. The first three years of operation have shown that loss of identity is not an issue and confirmed that the core challenge of the merge was the progressive realignment of the activity of the research groups in the framework of the main work areas of the common thematic strands. It was not expected, and it should not be expected, that groups with long-established areas of operation would immediately readjust and start new forms of cooperation. Previous commitments must be met and new opportunities cannot be lightly discarded. Moreover, it takes time and sustained internal proactive policies to prove that individual- and group-level performances directly benefit from cooperation.



The 2017 results show that the economic recovery caused a slight increase in the income from specialized consultancy. On the other hand, research funding reached a new minimum; this type of income was affected more than what was predicted in 2013 due to the impact of the funding rules for the Lisbon region in P2020 projects, the repercussion of the last evaluation that CERIS finds unjust and also the delay in the release of the results of the FCT calls for research projects.

The effects of the very limited funding secured by CERIS are already slightly visible in the performance indices registered in 2013-2017 and most probably they will affect the performance in the next few years. The level of competitiveness in national research project grants decayed mostly because of the discouraging discriminatory conditions the universities located in the Lisbon area have to face when applying to Portugal 2020 calls. In addition, and as a direct consequence of the downgrading suffered in the 2013 evaluation, core funding was substantially reduced and the funding necessary to launch the internal cooperation program was denied. It will have to be compensated, to a lesser extent, by alternative funding sources, namely international projects; in this respect, CERIS members have been very active in 2017 in drafting proposals for research projects.

Based on the high-level of the activities of CERIS in the 2013-17 period, in the recent evaluation exercise of early 2018, CERIS expects to regain the leading position in the Civil Engineering area. Such a result would be coherent with all main international scientific rankings where the University of Lisbon (in which CERIS is the only research unit in Civil Engineering) ranks 1<sup>st</sup> in the country in that subject. Furthermore, in the two most prestigious university rankings (Shanghai and Taiwan), the University of Lisbon is ranked 7<sup>th</sup> and 8<sup>th</sup> in Civil Engineering in Europe in 2017.

## **ANNEX A - PHD THESES COMPLETED IN 2017**

## A. PhD theses completed

1. Ana Isabel da Rocha e Sá Lopes Quaresma (2017): Developing pool-type fishways based on physical and numerical modelling of flows. PhD in River Restoration and Management, IST/UL. Supervisor(s): António Pinheiro
2. André Belejo (2017): Soil-structure interaction for reinforced concrete building structures. PhD in Civil Engineering, Oregon Univ. (USA). Supervisor(s): Rita Bento
3. Andrés José Prieto Ibáñez (2017): Application of an expert system based on fuzzy logic for the estimation of the functional service life of a set of homogenous buildings. PhD in Architecture, Univ. Sevilla (Spain). Supervisor(s): Ana Filipa Ferreira da Silva Cigarro Matos
4. Artur Tiago Carvalho de Freitas Silva (2017): Nonstationarity and uncertainty of extreme hydrological events. PhD in Civil Engineering, IST/UL. Supervisor(s): Maria Manuela Portela
5. Beatriz da Conceição Penhasco Massena Teles Claudino (2017): Reliability assessment of the direct displacement based design methodology. PhD in Civil Engineering, IST/UL. Supervisor(s): Rita Bento
6. Carina Alexandra Capela Pais (2017): A Colmatação Estruturante - Conceito Instrumental para o Ordenamento da Cidade. PhD in Territorial Engineering, IST/UL. Supervisor(s): Beatriz Condessa
7. Carlos Octávio Simões Mendes Fernandes (2017): Simulation of the behaviour of quasi-fragile materials using the discrete crack approach. Simulação do comportamento de materiais quase-frágeis utilizando a abordagem de fenda discreta. PhD in Civil Engineering, IST/UL. Supervisor(s): Eduardo Júlio; Jorge Alfaiate
8. Carolina Mónica Gonçalves Martins (2017): Understanding accessibility in cultural landscape sites - The case of Parques de Sintra - Monte da Lua, SA. PhD in Architecture, IST/UL. Supervisor(s): Teresa V. Heitor; Antonio Lamas
9. Cristina López Sánchez (2017): Numerical Modelling of the Thermomechanical Behaviour of GFRP Pultruded Profiles Submitted to Fire. Modelação numérica do comportamento termomecânico de perfis pultrudidos de GFRP sujeitos à acção de incêndio. PhD in Civil Engineering, IST/UL. Supervisor(s): Carlos Tiago; João R. Correia
10. Daniel da Costa Ribeiro (2017): Prediction of the hydro-mechanical behavior of jet-grouting columns made of soil-cement mixtures. PhD in Civil Engineering, IST/UL. Supervisor(s): Rafaela Cardoso
11. Dimitrios Papaioannou (2017): Assessing the Relation Between Mode Choice, User Satisfaction, and Quality for Public Transport Systems. PhD in Transportation Systems, IST/UL. Supervisor(s): Luís Martínez; Luís Picado Santos
12. Diogo André Gomes Pedro (2017): High-performance concrete with recycled aggregates from the precasting industry. Betão de elevado desempenho com agregados reciclados provenientes da indústria de pré-fabricação. PhD in Civil Engineering, IST/UL. Supervisor(s): Jorge de Brito; Luís Evangelista
13. Duarte Gil Ferreira Marques Nunes (2017): Regenerative Architectures - Strategies for an Integrated Urban Intervention. Arquitecturas Regenerativas - Estratégias para uma Intervenção Urbana Integrada. PhD in Architecture, IST/UL. Supervisor(s): Ana Tomé; Manuel Pinheiro
14. Eglė Bazaraitė (2017): Embodying paradise: silent cities and sacred groves on the margins of Europe. Roman Catholic cemeteries in Lithuania and Portugal. PhD in Architecture, IST/UL. Supervisor(s): Teresa V. Heitor
15. Fátima Maria Pereira Gouveia (2017): In situ dynamic characterization in urban environment. Caracterização dinâmica in situ do terreno em meio urbano confinado. PhD in Civil Engineering, IST/UL. Supervisor(s): Isabel Lopes; Rui Carrilho Gomes
16. Gustavo Meireles Lima (2017): Pumps as turbines to replace pressure reducing valves. PhD in Civil Engineering, Universidade Estadual de Campinas (Brazil)/IST. Supervisor(s): Helena M. Ramos
17. Hawreen Hasan Ahmed (2017): Cementitious Materials Reinforced with Carbon Nanotubes. PhD in Civil Engineering, IST/UL. Supervisor(s): José Alexandre Bogas; Fernando Branco

18. João Miguel Gomes Pires Manso (2017): Predicting the Behaviour of Rockfill Embankments. PhD in Civil Engineering, IST/UL. Supervisor(s): Rafaela Cardoso
19. Maria Catarina Custódio da Paz (2017): Geophysical techniques applied to shallow aquifers characterization. PhD in Georesources, IST/UL. Supervisor(s): Luis Ribeiro
20. Maria Luísa Cannas da Silva Kuhn Videira (2017): Campus as a City - City as a Campus A morphological approach to university precincts in urban context. PhD in Architecture, IST/UL. Supervisor(s): Teresa V. Heitor
21. Mariana de Campos Madeira Simão (2017): Fluid structure interaction in pressurized systems. PhD in Civil Engineering, IST/UL. Supervisor(s): Helena M. Ramos
22. Modesto Pérez-Sánchez (2017): Irrigation networks towards sustainability and efficiency. PhD in Civil Engineering, UPV/ IST. Supervisor(s): Helena M. Ramos
23. Orga Petrik (2017): Uncertainty Analysis in Travel Demand Modelling. PhD in Transportation Systems, IST/UL. Supervisor(s): Filipe Moura; João Abreu e Silva
24. Paulo Alexandre Fernandes Varela Simões Caldas (2017): Local government strategic management. PhD in Economics, University of New England, Armidale. Supervisor(s): Rui Cunha Marques
25. Paulo Renato Amaral Rego (2017): Femoroacetabular impingement: a contribution to the knowledge of the physiopathology and analysis of the results of the chirurgyConflito femuro acetabular: contributo para conhecimento da fisiopatologia e análise dos resultados da cirurgia. PhD in Medicine, Fac. Medicina, U Lisboa. Supervisor(s): Fernando Simões
26. Pedro Ricardo Neto Póvoa (2017): Contributions for modeling strategies and operational management of large water resource recovery facilities with combined sewer systems inflow. PhD in Environmental Engineering, IST/UL. Supervisor(s): José Saldanha Matos
27. Rawaz Mohammed Saleem Kurda (2017): Sustainable development of cement-based materials: Application to recycled aggregates concreteDesenvolvimento sustentável de materiais de base cimentícia. Aplicação a betão com agregados reciclados. PhD in Civil Engineering, IST/UL. Supervisor(s): José Dinis Silvestre; Jorge de Brito
28. Rita Cláudia Jorge Peres (2017): Performance based seismic design and assessment of 3D irregular steel structures. PhD in Civil Engineering, IST/UL. Supervisor(s): Rita Bento
29. Rita Oliveira Mota Amaral (2017): Planeamento Estratégico de Investimentos nos Serviços de Águas, em Portugal. PhD in Civil Engineering, IST/UL. Supervisor(s): José Saldanha Matos
30. Rui Twohig Hugman (2017): Applicability of different numerical approaches to defining boundary conditions and density-driven flow in groundwater flow and transport models – from regional scale management to submarine groundwater discharge. PhD in Marine, Earth and Environmental Sciences, Univ. Algarve. Supervisor(s): José Paulo Patrício Gerales Monteiro
31. Sérgio Cançado Paraíso (2017): A critical analysis of dynamic increasing energy tests on high capacity pilesAnálise crítica de ensaios de carregamento dinâmico de energia crescente em estacas de elevada capacidade resistente. PhD in Civil Engineering, IST/UL. Supervisor(s): Jaime Santos
32. Sílvia Rute Caleiro Amaral (2017): Experimental characterization of the failure by overtopping of embankment dams. PhD in Civil Engineering, IST/UL. Supervisor(s): Rui M. L. Ferreira
33. Susana Cristina dos Santos Gomes Martins Moretto (2017): Techhnology Assessment and High - Speed Trains: facing the challenge of emergent digital societal. PhD in Technology Assessment, FCT, Univ. Nova de Lisboa. Supervisor(s): Rosário Macário
34. Vikas Laxman Gingine (2017): Soft soils consolidation and decontamination using electrokinetical methods. PhD in Civil Engineering, IST/UL. Supervisor(s): Rafaela Cardoso
35. Warlley Soares Santos (2017): On the Strength and DSM Design of End-Bolted Cold-Formed Steel Columns Buckling in Distortional Modes. PhD in Civil Engineering, Universidade Federal do Rio de Janeiro (Brazil). Supervisor(s): Dinar Camotim

36. Zélia da Conceição Costa Coelho Santos (2017): Urban Morphology and its impact on public healthA Morfologia da Cidade e as Consequências para a Saúde Pública. PhD in Public Health, UNL/IHMT.  
Supervisor(s): Miguel Amado



## **ANNEX B - PAPERS PUBLISHED IN ISI/SCOPUS JOURNALS IN 2017**

## B.1. Papers in ISI journals

1. Abreu e Silva, J.; Alho, A.R. (2017): "Using Structural Equations Modeling to explore perceived urban freight deliveries parking issues", *Transportation Research Part A: Policy and Practice*, V. 102, 18-32, August 2017. DOI:10.1016/j.tra.2016.08.022
2. Alfaiate, J.; Sluys, L.J. (2017): "On the modeling of mixed-mode discrete fracture: part I - damage models", *Engineering Fracture Mechanics*, V. 182, 157-186, September 2017. DOI:10.1016/j.engfracmech.2017.07.019
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5. Al-Mansouri, T.; Micaelo, R.; Artamendi, I.; Norambuena-Contreras, J.; Garcia, A. (2017): "Microcapsules for self-healing of asphalt mixture without compromising mechanical performance", *Construction and Building Materials*, V. 155, 1091-1100, November 2017. DOI:10.1016/j.conbuildmat.2017.08.137
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10. Alves, M.; Carreira, P.; Costa, A.A. (2017): "BIMSL: A generic approach to the integration of building information models with real-time sensor data", *Automation in Construction*, V. 84, 304-314, December 2017. DOI:10.1016/j.autcon.2017.09.005
11. Alves, R.; Faria, P.; Simão, J. (2017): "Experimental characterization of a Madeira Island basalt traditionally applied in a regional decorative mortar", *Journal of Building Engineering*, V. 13, pp. 326-335, September 2017. DOI:10.1016/j.jobbe.2017.09.004
12. Amado, M.; Poggi, F.; Amado, A.R.; Breu, S. (2017): "A cellular approach to net-zero energy cities", *Energies*, V. 10, n.º 11, art. 1826, November 2017. DOI:10.3390/en10111826
13. Amado, M.P.; Ramalhete, I.; Amado, A.R.; Freitas, J.C. (2017): "Inclusive housing program: The case of Oé-Cusse region in East Timor", *Frontiers of Architectural Research*, V. 6, n.º 1, pp. 74-88, March 2017. DOI:10.1016/j.foar.2016.12.001
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