CERIS : Civil Engineering Research and Innovation for Sustainability

CERIS - CIVIL ENGINEERING RESEARCH AND INNOVATION FOR SUSTAINABILITY

Scientific Report 2016

Programmed Research for 2017

EXECUTIVE BOARD

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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 2016, CERIS had 129 PhD members, 89 PhD collaborators and 258 PhD students enrolled at IST and grant holders 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 (DECivil) and Georresources, 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 second report on the scientific activity of CERIS. Besides consolidating the 2016 reports of its founding centres, it is necessary to define the positioning of the new unit in the national context and to address 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 2016 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 2016 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 2017 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) Researchers maintained in 2016 their levels of national and international visibility. They participated in the organization of 29 (11) international (national) events and in the scientific committees of 136 (92) events. Membership of editorial boards remained strong (40 national and 109 international, of which 13 Associate Editor and 3 Editor-in-Chief roles in international journals), as well as the participation in technical committees for drafting codes and standards (72 national and 63 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 has held in 2016, with a ratio of 2.1 per PhD member. The ratios for publication in conference proceedings were 1.5 and 2.2 per PhD member in national and international conferences, respectively.
5) The number of PhD theses concluded in 2016 (40), as well as the number of co-supervised doctoral students (232 registered in IST-UL and 70 in other institutions), have also been increasing over the last decade. The ratios per PhD member (0.3 concluded theses and 2.3 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. Sustainment of the 2016 performance indices in 2017-2018 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 was given in the 2008-2012 evaluation of the Portuguese research units, which is still in dispute. 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. Funding from contracted research increased until 2015 since the lowest value registered in 2012, but it reached a new minimum in 2016, with a net income in 2016 63% lower than 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 2016 net income from competitive research funding was 64% of the 2008-2012 average.
9) The income sources were balanced in that period, with 52% of the budget sourced from competitive research funds and 48% from contracted research. The 2016 budget (ca. 2.1 M€) was 50% of the 2008-2012 average (ca. 4.3 M€) and the profile of the budget changed. In 2016, 60% of the budget was sourced from competitive research and 40% from contracted research. These values have been highly unstable in the last few years, e.g. in 2015 they were more or less even.
10) These changes were caused by the conjugation of the adverse conditions identified above. FCT has announced a new evaluation of the research units in late 2017. 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 2016, CERIS joined the expertise of 129 PhD members and 89 PhD collaborators (this distinction is explained below) and 258 non-PhD researchers (PhD students enrolled at IST and project grant-holders). 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.

CEHIDRO | Centre of Hydraulics, Water Resources and Environment

CEHIDRO develops research and consultancy in the areas of hydraulics, water resources and environment. In 2016, CEHIDRO had 25 PhD members, 8 PhD collaborators and 76 PhD students, for a total of 109 researchers organized in three research groups (RG): Environment, Water Resources and Water Services (RG4); Hydrogeology and Geo-systems (RG5); Pressurized, Fluvial and Maritime Hydraulic Systems (RG9).

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 2016, CESUR had 25 PhD members, 27 PhD collaborators, 78 PhD students, for a total of 130 researchers. CESUR's activity is organized in three groups: Urban Planning and Environment (RG3); Systems and Management (RG7); Transport Infrastructure, Systems and Policy.

ICIST | Institute of Structural Engineering, Territory and Construction

The core areas of ICIST are Structural Engineering, Construction and Architecture. In 2016, ICIST comprised 79 PhD members, 54 PhD collaborators and 153 PhD students, a total of 286 researchers, organized in seven groups: Architecture (RG1); Earthquake Engineering and Seismology (RG2); Information and Design Support Systems (RG6); Mechanics, Modelling and Analysis of Structures (RG8); Structural Design and Geotechnics (RG10); Studies in Construction (RG11); Concrete Structures (RG13).

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, ISISE, 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 2016*

Domain	CERIS	CONSTRUCT	ISISE	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 was 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 is 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 is still disputing 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. In 2016 FCT announced that a new evaluation, independent from the previous one, was going to be held at roughly the end of 2017.

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.

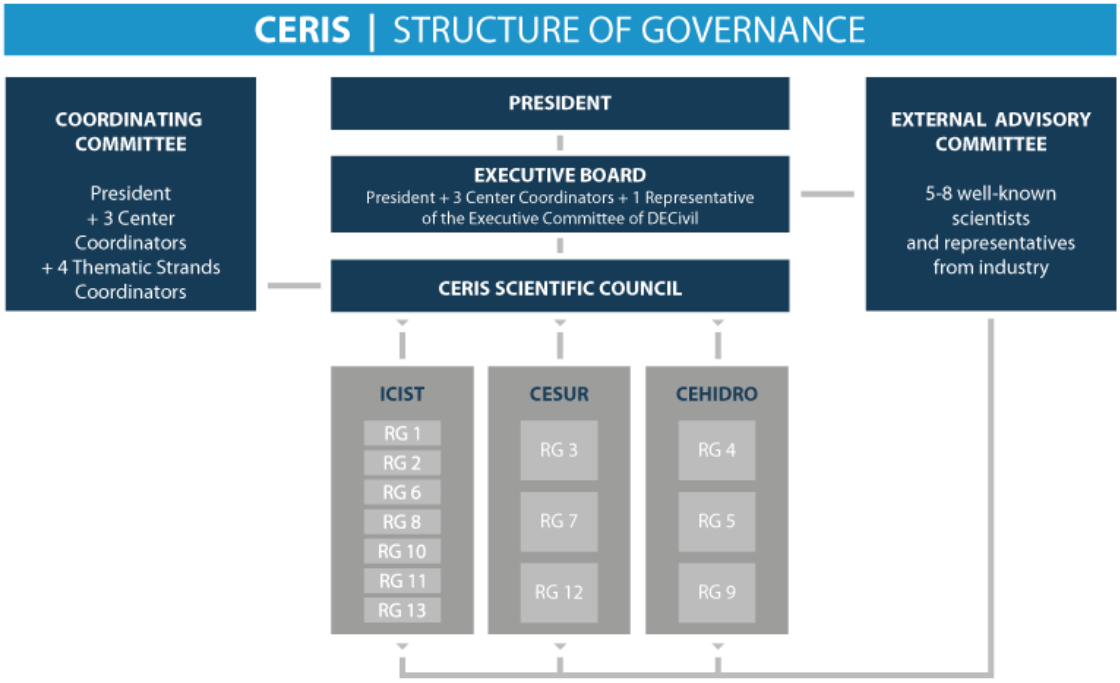

Figure 1 | Structure of governance in 2016

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 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 13 research groups. Their coordinators in 2016 are identified in Table 3 and Table 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	Teresa Heitor	ICIST
RG2	Earthquake Engineering and Seismology	João Azevedo	ICIST
RG3	Urban and Regional Planning and Environment	João Abreu e Silva	CESUR
RG4	Environment, Water Resources and Water Services	José Saldanha Matos	CEHIDRO
RG5	Hydrogeology and Geo-systems	Luís Ribeiro	CEHIDRO
RG6	Information and Design Support Systems	António Costa	ICIST
RG7	Systems and Management	Rui Cunha Marques	CESUR
RG8	Mechanics, Modelling and Analysis of Structures	Dinar Camotim	ICIST
RG9	Pressurized, Fluvial and Maritime Hydraulic Systems	António Pinheiro	CEHIDRO
RG10	Structural Design and Geotechnics	Pedro Mendes	ICIST
RG11	Studies on Construction	Jorge de Brito	ICIST
RG12	Transportation Infrastructure, Systems and Policy	Luís Picado Santos	CESUR
RG13	Concrete Structures	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

Advisor	Institution
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 and coordination and participation in concluded competitive research projects. 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 are not too demanding and will be increased by 30% from 2016 onwards. Presently, and assuming that no other scientific activity is reported, a PhD researcher would reach the 2016 membership conditions publishing in a Quartile 1 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 2016. The 2016 distribution of researchers is summarized in Table 6. They include academic staff of UL and of twelve other universities and polytechnics[1].

[1] U. Algarve, U. Beira Interior, U. Coimbra, U. Évora, U. Nova de Lisboa, U. Madeira, U. Estadual Campinas (Brazil), U. Federal Santa Catarina (Brazil), Instituto Superior de Engenharia de Lisboa, Instituto Superior de Engenharia de Coimbra, Instituto Politécnico de Setúbal, Instituto Politécnico de Leiria.

Table 6 | Profile of research staff

Centre	Integrated members	PhD researchers		PhD students	
		Members	Collaborators	CERIS-IST	External
CEHIDRO	20	25	8	64	12
CESUR	19	25	27	58	20
ICIST	53	79	54	114	39
CERIS	**92**	**129**	**89**	**232**	70

1.6 Administrative and technical staff

In 2016 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 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.

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.

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.

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

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 two 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 2016 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 2016 are also summarized to support the analysis of three key aspects in a new unit merging centres that used to operate independently: the 2016 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 2016 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 2016, 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, on 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 and the Portuguese Water Partnership.

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	RG8	RG9	RG10	RG11	RG12	RG13
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 2016, 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).

RG1 | Architecture

7 PhD members | 11 PhD collaborators | 32/10 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 2016, RG1 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 (RG2, 3, 6, 11, 12) 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.

RG2 | Earthquake Engineering and Seismology

11 PhD members | 4 PhD collaborators | 13/2 PhD students (CERIS-IST/External)

The activity in RG2 includes studies about global earthquake losses and structural safety for seismic loading, namely analysing:

- 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.

Besides joint work with RG1, RG6, RG10 and RG11, in 2016 RG2 maintained a strong cooperation with Portuguese institutions such as LNEC, CINAMIL, STAP and Infraestruturas de Portugal S.A. and with international institutions such as U. Nice, Institut de Physique du Globe de Paris, UMR Sisyphe, U. Pierre et Marie Curie and IFPEN (France); Ludwig Maximilians U. - LMU Munich (Germany); Oregon U., U. Michigan and U. California (USA); Oxford U. and Sheffield Hallam U. (UK); U. Granada (Spain); TU Delft (Netherlands); Tehran University of Science and Technology (Iran); Direcção Nacional de Geologia (Mozambique); National Institute of Meteorology and Geophysics (Cape Verde); U. Pavia, U. Padova, U. Genoa and Istituto Nazionale

di Geofisica e Vulcanologia - INGV (Italy), and Earthquake Engineering Research Centre - EERC (Iceland). Research on the design and implementation of seismic protection devices was developed in collaboration with industrial partners, namely PRETENSA (Portugal), FIP Industriali (Italy) and Taylor Devices (United Kingdom). Group members participate in the Board of Directors of SPES - Portuguese Society for Earthquake Engineering, EAEE - European Association for Earthquake Engineering, SPEHC - Portuguese Society for Studies on Construction History and the PTPC Rehabilitation Working Group.

One group member was External examiner in the MSc cluster in structural engineering (earthquake, steel, concrete, general) at Imperial College, London.

RG3 | Urban and Regional Planning and Environment
9 PhD members | 7 PhD collaborators | 7/9 PhD students (CERIS-IST/External)

The RG3 objectives 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 2016, RG3 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).

RG4 | Environment, Water Resources and Water Services
8 PhD members | 0 PhD collaborators | 26/3 PhD students (CERIS-IST/External)

The activity of RG4 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.

In 2016, joint research work has been developed with the National Civil Engineering laboratory (LNEC), the Regulatory Entity for Water and Waste (ERSAR), the Portuguese Agency for the Environment (APA) and with Águas de Lisboa e Vale do Tejo, among other national Institutions, and with a large number of partners of foreign countries (namely Denmark, Spain, Switzerland and Cape Verde). Water resources and environmental issues have been addressed in cooperation, namely with RG5, RG7, RG9 and RG 10.

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

RG5 | Hydrogeology and Geo-systems
6 PhD members | 1 PhD collaborator | 2/7 PhD students (CERIS-IST/External)

The activity of RG5 is focused on the following topics:

- 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 2016, RG5 carried out joint research on several issues with the following institutions: (i) Mine Water and Environment (Oviedo U.); (ii) Groundwater and Global Change (IHE-UNESCO, The Netherlands); (iii) Decision support systems for water catchment management (ESPOL, Guayaquil, Ecuador); (iv) Stochastic and Groundwater Numerical Modelling (University of Tunis El Manar, Faculty of Sciences of Tunis, Tunisia; (v) Quantitative Hydrogeology (U. Antioquia, Colombia); (vi) Groundwater Modeling of North Peruvian aquifers (COOPERACIÓN y Regional Government of Lima, Peru); (vii) Trend analysis of hydrogeological variables (APA, Portugal); (viii) Urban hydrogeology (Lisbon Municipality). In terms of internal collaborations within CERIS, the group interacts with RG5 and RG11.

RG6 | Information and Design Support Systems
5 PhD members | 2 PhD collaborators | 6/2 PhD students (CERIS-IST/External)

RG6 is focused on Digital and Information Systems in the context of the Built and Natural Environment sector. In 2016, 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 2016, members of RG6 co-supervised MSc dissertations and PhD theses developed in cooperation with LNEC, U. Aveiro, U. Algarve, U. Évora, ISCTE, IP Leiria and U. São Paulo, and participated in research projects with research centers of U. Católica Portuguesa (CITAR), U. Lisboa (CERENA) and UF Rio de Janeiro. Internal cooperation was wide, involving groups RG1 to RG4, RG7 and RG10 to RG12. RG6 participated in several standardization projects, which involved more than 40 companies.

RG7 | Systems and Management

6 PhD members | 8 PhD collaborators | 19/3 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.

In 2016, RG7 cooperated with groups RG3, RG4, RG6, RG10 and RG12 and with researchers from Portuguese institutions (Portuguese Agency for the Environment, ERSAR, ERSARA, U. Lisboa, U. Aveiro). 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. Brasilia, 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.

RG8 | Mechanics, Modelling and Analysis of Structures

13 PhD members | 7 PhD collaborators | 5/5 PhD students (CERIS-IST/External)

RG8 merges two former research groups working in finite element modelling of nonlinear structural behaviour, one specialized in conventional formulations and the other on hybrid formulations (with similar sizes) - the merge took place in 2008. The work of RG8 evolved to focus mainly on analysis and design of thin-walled steel and composite (steel-concrete and FRP) structures and on structural multi-physics problems. The activity in 2016 addressed two main topics:

- Analysis and design of thin-walled steel structures, via either Generalized Beam Theory (GBT) or commercial software, and participation in experimental investigations. There is considerable in-house expertise in this field, particularly on the development, implementation and application of GBT

formulations and the analysis and design of cold-formed steel members and structural systems;

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

In 2016, members of RG1 co-supervised doctoral theses developed in cooperation with other schools of U. Lisboa and with U. Lusíada and U. Porto, as well as U. Chongqing, EPFL and MIT, the last two under joint initiatives. RG1 cooperated in research with most groups of CERIS (RG2, RG3, RG6 and RG9 to RG12) and continued to cooperate in 2016 with researchers of other national institutions (INESC and LNEC) and universities (U. Nova Lisboa, U. Porto). Besides a research contract with the Government of S. Tomé and Principe, cooperation in joint projects with foreign universities included U. Dili East Timor and U. Zaragoza. A group member acted as external expert for the OECD Centre for Effective Learning Environments.

RG9 | Pressurised, Fluvial and Maritime Hydraulic Systems
11 PhD members | 7 PhD collaborators | 35/2 PhD students (CERIS-IST/External)

The activity of RG9 in 2016 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 2016, RG9 members coordinated and supervised doctoral theses of two FCT funded doctoral initiatives (Table 11) developed in cooperation with other universities (EPFL, Instituto Superior de Agronomia of U. Lisboa) and LNEC. RG9 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. Perugis, 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 RG3, RG4, RG6, RG10 and RG12 under national projects.

RG10 | Structural Design and Geotechnics

9 PhD members | 5 PhD collaborators | 12/1 PhD students (CERIS-IST/External)

RG10 comprises three research areas on Steel and Composite Structures, Bridge Design and Geotechnics. The activity of RG10 in 2016 was organized in the following main topics:

a) 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.

b) Bridge Design (steel and composite steel-concrete bridge decks)

- Warping and distortion of box-girder decks;
- Buckling of curved and tapered plate girders panels;
- Buckling resistance of steel plated girders considering M-V interaction with high compression forces.

c) 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 2016, members of RG10 co-supervised doctoral theses developed in cooperation with other universities, namely with EPFL (Switzerland), Univ. Pavia (Italy) and U. São Paulo (Brazil). Members of RG10 are part of the Editorial Board of seven International Journals and have made part of the Scientific Committee of five International events that took place in 2016. The members of RG10 are strongly involved in the Drafting of Recommendations and Codes and during 2016 continued to cooperate with researchers of national institutions (ITQB, INESC, LNEC, U. Nova Lisboa, U. Aveiro, FEUP) and foreign institutions (such as EPFL, UP Catalunya, UP Cartagena, NTNU, U. Pavia, TU Delft), besides the collaborations with other groups of CERIS (such as RG2, RG4, RG7 and RG9). In partnership with other institutions, two international research grants were awarded within the Research Programme of the Research Fund for Coal and Steel.

RG11 | Studies on Construction

26 PhD members | 9 PhD collaborators | 43/10 PhD students (CERIS-IST/External)

RG11 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 2016, members of RG11 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) and foreign institutions (EPFL, TU Delft, ETH Zurich, UE Campinas, UE Maringá, UF Brasília, U. Stavenger, U Léon, U Sevilla, U. Cordoba, UST Iran, UP Madrid, 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, U Aveiro, U. Porto, U Lisboa, U Nova Lisboa) and foreign universities (ENTPE Lyon, TU Delft, FAU-USP, TU Cluj Napoca, U. Ghent, U. Stavenger). Joint research projects were developed with LNEG, U. Nova Lisboa, LNEC, U. Lisboa and U. Minho.

RG12 | Transportation Infrastructure, Systems and Policy
10 PhD members | 12 PhD collaborators | 34/8 PhD students (CERIS-IST/External)

RG12 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, 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 2016, and following the previous years, the international activity of RG12 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 and AFIF), 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.

RG13 | Structural Concrete

8 PhD members | 16 PhD collaborators | 11/10 PhD students (CERIS-IST/External)

The activity of RG13 in 2016 was organized in the following main topics:

- 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.

In 2016, members of RG13 co-supervised post-doc, doctoral and master students in cooperation with different institutions, namely LNEC, IST, U. Lisboa, U Nova de Lisboa, Academia Militar, U. Minho, U. Coimbra, U. Madeira, IP Coimbra, IP Leiria, IP Lisboa. In this scope, the Joint Post-Doctoral Program between U. Nova de Lisboa and Imperial College London, funded by the SNSF - Swiss National Science Foundation, and the Joint Doctoral Program between IST and Université Paul Sabatier Toulouse III, are highlighted. Members have been active in different commissions and working groups of International, European, North-American, South-American, and National technical associations, such as fib, ICOMOS, CEN, TRB, IBRACON, IPQ, and GPBE. The development of research projects also involved cooperation with both international, foreign, and national companies, such as VSL, Itaipu Binacional, Concremat, Vamaro, Lena, Smart Innovation, Solancis, and Vigobloco.

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. Internal cooperation was not questioned in the last evaluation held when the centres still operated independently (2007). The evaluation panel found that the existing forms of cooperation (shaded cells in Table 9 | Group cooperation) were coherent with the work areas of the research groups of each centre. However, these issues must be reassessed in consequence of the objectives set in the merge of the CERIS founding centres.

To that effect, the information given in Table 8 is used in Table 9 | Group cooperation to identify all potential forms of cooperation in the development of the thematic strands (identified in Table 9 | Group cooperation by digits 1 to 4). This overlapping is indicative as one cannot expect direct cooperation between all groups participating in a given thematic strand. Thus, digits in bold are used to identify the direct collaborations that can be realistically expected according to the profiles of the groups.

Table 9 | Group cooperation (collected in early 2016) and expectable cooperation in thematic strands

Groups	RG2	RG3	RG4	RG5	RG6	RG7	RG8	RG9	RG10	RG11	RG12	RG13	Centre
RG1	**3**	**3**		3	**1**;3		1;3	**3**	**3**	**1**;3	**1**;3	**3**	**ICIST**
RG2	**2**;3	**2**	2;3	**3**	2	**3**	2;3	**2**;3	**2**;3	**2**;3	**2**;3	**ICIST**
RG3	2;4	2;3	**3**	2;4	3	2;3	2;3	2;3	2;3;4	2;3;4	2;3	**CESUR**
RG4	2	**3**	2;4		**2**	2	2;4	2;4	2	**CEHIDRO**
RG5		2	3	2;3	2;3	2;3	2;3	2;3	**CEHIDRO**
RG6		1;3	**3**	**3**	1;3	1;3	**3**	**ICIST**
RG7		2	**2**	2;4		**2**	**CESUR**
RG8	3	**3**	**1;3**	**1;3**	**3**	**ICIST**
RG9	2;**3**	2;3	2;3	2;**3**	**CEHIDRO**
RG10	**2**;3	**2**;3	**2**;3	**ICIST**
RG11	1;3	**2**;3	**ICIST**
RG12	**2**;3	**CESUR**
RG13	**ICIST**

: Existing forms of cooperation
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

The information summarized in Table 9 | Group cooperation (collected in early 2016) indicates the collaborations developed when the centres operated independently and in domains covered by the thematic strands. They justify their merge to create CERIS: inherent complementarity and key synergies in the wider sector of Built and Natural Environment. It was not expected, because it would be unrealistic, that research groups with long established areas of operation would immediately readjust and start cooperating. Previous commitments must be met and it takes time and proactive policies to prove that cooperation improves individual- and group-level performance.

The main instrument envisaged to promote cooperation was an internal seeding program. As the funding allocated to that program was denied in consequence of the results of the 2013 evaluation, in 2016 CERIS used funding generated through consultancy and on-going training to promote internal cooperation

projects. This policy is instrumental to support the regular reassessment of the main work areas of the thematic strands with the objective of combining different forms of expertise to strengthen the impact of the combined output of the unit.

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 11** shows that CEHIDRO and CESUR have attained good ratios of PhD students per PhD member. The relative weight of ICIST pulls the overall ratio down to 2.34, within a 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 0.8 and 7.0, both registered in ICIST.

Table 12 | Profile of research centres

Centre	PhD researchers		PhD students		Ratios per PhD member	
	Members	Collaborators	CERIS-IST	External	PhD collaborators	PhD students
CEHIDRO	25	8	64	12	0.32	3.04
CESUR	25	27	58	20	1.08	3.12
ICIST	79	54	114	39	0.68	1.94
CERIS	**129**	**89**	**232**	**70**	**0.69**	**2.34**

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 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. Three 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 2016, 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. The third reason is that the 2016 PhD collaborators were selected by the founding centres according to their own criteria, as those set by the Scientific Council of CERIS only took effect in 2016 for new admissions.

Data given in **Table 13** suggest that the proportion of PhD collaborators is high, particularly in CESUR and ICIST. The deviation of the ratios at group level is again substantive, within and across centres.

CERIS must face this issue and implement from 2017 onwards a clear policy on academic staff not meeting the membership requirements on scientific performance. It should target those who have

experienced circumstantial difficulties in raising research funds and it should foment their engagement in doctoral supervision, either by reallocation to better performance teams or through internal doctoral grant programs. It also should limit the probation period for those who do not succeed in those initiatives, as this form of affiliation is statutorily transient.

2.7 Reorganization of the research groups

The last issue addressed here is the reorganization of the research groups. The work areas identified in Section 2.4 confirm that the internal organizations of CEHIDRO and CESUR stabilized before their merge in CERIS and reflect the successive expansions and consequent adjustments of the larger centre, ICIST.

Because this issue may compromise key aspects in what concerns the evolution and future evaluation of CERIS, a process of reorganization was completed in 2016 (to be effective in 2017) from which resulted a new list of research groups (Table 14).

Table 11 | Research Groups (before and after the reorganization process)

Before		**After**	
Group	**Designation**	**Group**	**Designation**
RG1	Architecture	RG1	Architecture, Urbanism and Territory
RG3	Urban and Regional Planning and Environment		
RG9	Pressurized, Fluvial and Maritime Hydraulic Systems	RG2	Hydraulics
RG4	Environment, Water Resources and Water Services	RG3	Environment and Water Resources
RG5	Hydrogeology and Geo-systems		
RG6	Information and Design Support Systems	RG4	Systems and Management
RG7	Systems and Management		
RG12	Transportation Infrastructure, Systems and Policy	RG5	Transportation Systems
RG11	Studies on Construction	RG6	Studies on Construction
RG2	Earthquake Engineering and Seismology	RG7	Structures and Geotechnics
RG8	Mechanics, Modelling and Analysis of Structures		
RG10	Structural Design and Geotechnics		
RG13	Concrete Structures		

The rationale behind this reorganization was the following:

- To increase the scientific impact needed for all research groups to be national leaders in their area (and often international leaders);
- To guarantee that all research groups have a viable critical mass free from problems related with aging of their members;
- To achieve a clear horizontal thematic organization of the research areas;
- To reduce the organizational entropy resulting from an excessive number of research groups.

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 2016. The second part of this section summarizes the 2016 activity indicators and the third 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 2014 to 2016. Section 3 closes with the summary of the 2016 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 152, 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 15 | Participation in doctoral programs

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

(1) Coordinated by CERIS members; (2) Funding until 2021; (3) 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 152 because the participation of CERIS is marginal.

3.2 Activity indicators

The main scientific outputs of CERIS in 2016 are presented in Table 163:

(i) 40 concluded PhD theses and 264 in progress (201 developed by CERIS-IST PhD students registered in IST and 63 by PhD students registered in other schools or universities);
(ii) 287 concluded MSc theses and 364 in progress (master students registered at IST);
(iii) 51 books (5 as book author, 38 as author of book chapters and 8 as book editor);
(iv) 301 papers published in international journals, among which 261 cited in ISI Web of Knowledge, 12 cited in Scopus database, and 28 papers published in other international journals;
(v) 286 papers published in international conference proceedings;
(vi) 197 papers published in national conference proceedings.

Table 16 | 2016 activity indicators: theses and publications

ACTIVITIES			CEHIDRO	CESUR	ICIST	CERIS
Academic research work	PhD theses	Concluded	10	14	16	40
		In progress: CERIS-IST students	55	46	105	201
		In progress: external students	11	19	34	63
	MSc theses	Concluded	36	39	215	287
		In progress	41	106	222	364
Publications	Papers in peer-reviewed journals	International journals: ISI	60	43	161	261
		International journals: Scopus	2	1	9	12
		National peer-reviewed journals	8	0	22	29
	Papers in other journals	International	6	5	17	28
		National	5	1	9	15
	Papers in proceedings	International	63	56	169	286
		National	42	32	127	197
	Books	Entire	0	0	5	5
		Chapters	2	13	23	38
		As editor	0	2	6	8
Reports			12	8	42	62

The number of papers published in international journals is higher than the number of communications presented in international conferences. 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 174, namely:

(i) Membership of editorial board of international journals (109);
(ii) Membership of editorial board of national (Portuguese and foreign) journals (40);
(iii) Peer-reviewing for several international journals (737) and national journals (31);
(iv) Participation in organizing committees of international conferences (47);
(iv) Participation in organizing committees of national conferences (18).

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

(i) 50 invited key-note lectures made in both international and national conferences;
(ii) 20 recognition awards (national and international);
(iii) Sustained academic and scientific cooperation with leading national and foreign universities and institutions.

Table 17 | 2016 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	12	18	79	109
		National	9	3	28	40
	Conference scientific committees	International	17	21	98	136
		National	23	4	65	92
	Drafting of codes, recommendations	International	5	1	66	72
		National	1	1	61	63
Organization of scientific events - membership of organizing committees		International	7	11	29	47
		National	4	3	11	18
Refereeing journals		International	104	82	557	743
		National	6	4	22	32
Refereeing for funding agencies (national and international)			6	2	40	48
Lectures by invitation in international conferences (plenary, keynote)			6	18	26	50
Lectures and/or organization of scientific or technical workshops, seminars, courses and similar (national and international)			19	53	61	133
Scientific cooperation		International	38	38	73	149
		National	23	2	94	119
Academic exchanges		International	10	16	12	38
		National	2	0	12	14
Awards (national and international)			1	0	19	20

The information presented in Table 185 summarizes the 2016 initiatives to obtain funding through competitive research and consultancy. As shown below in Figure 6, in 2016 the budget secured through competitive research projects (close to 1.26 M€) was nearly 1.5 times the budget secured through

consultancy (close to 0.85 M€). This means that, even though public research-funding fell sharply, the funding secured through specialized consultancy and industry-funded projects fell even more sharply (the worst year in record for decades). One was caused by the austerity policies applied by the government during the economic crisis and the other reflects the effect that the crisis had in the Construction sector.

Table 18 | 2016 activity indicators: research and consultancy contracts

ACTIVITIES			CEHIDRO	CESUR	ICIST	CERIS
Research grants for projects, sabbaticals, post-doc	International research grants	Submitted	15	0	19	34
		Awarded	2	1	8	11
		In progress	4	5	14	23
	National research grants	Submitted	9	1	10	20
		Awarded	2	1	10	13
		In progress	7	3	28	38
Individual PhD grants		Submitted	3	3	7	14
		Awarded	17	17	8	26
Consultancy projects and industry contract research projects			15	23	15	57

The indicators presented in Table 196 (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 19 | 2016 activity indicators: other initiatives

ACTIVITIES		CEHIDRO	CESUR	ICIST	CERIS
Models		2	0	0	2
Software applications		4	0	1	5
Pilot plants		3	0	1	4
Patents	National	0	0	0	0
	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.

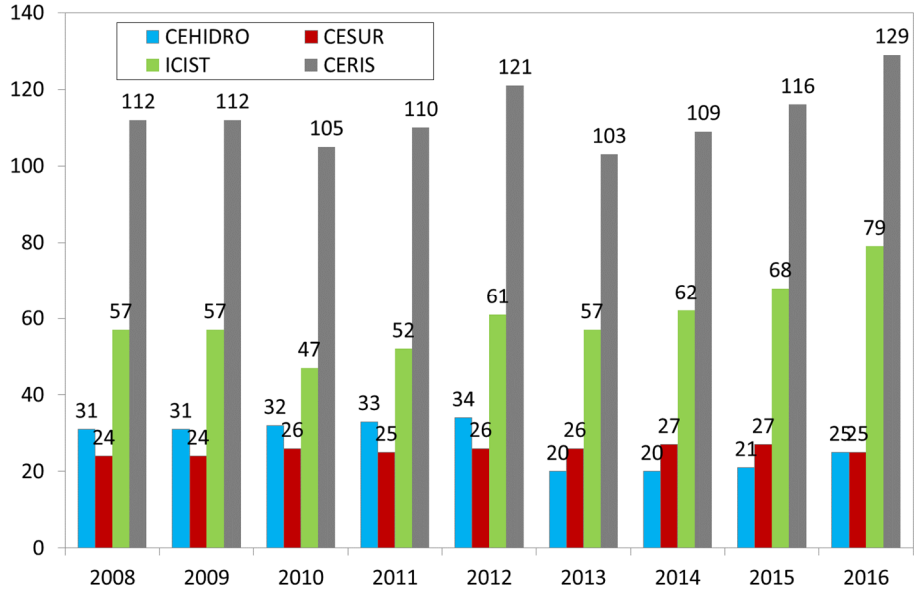

Figure 2 | Evolution of PhD members

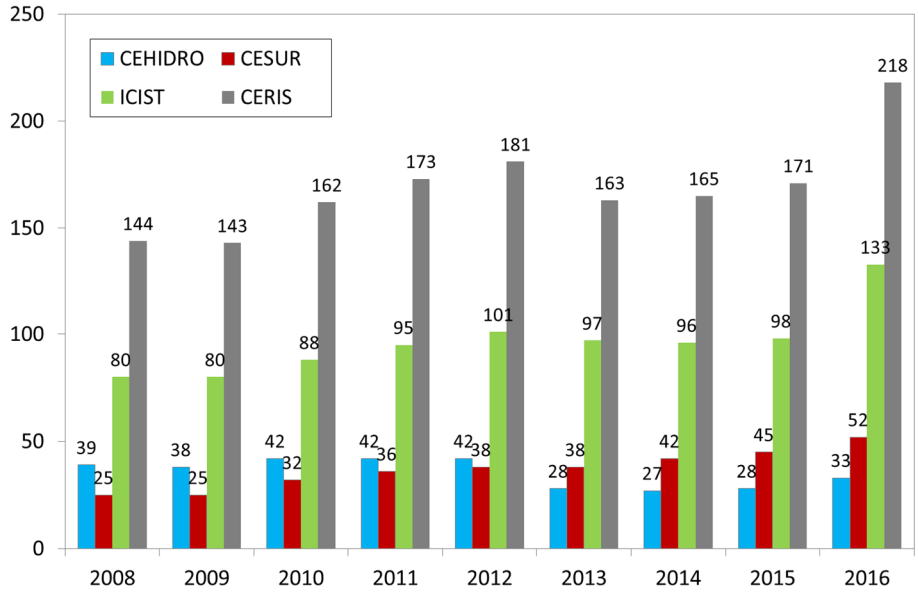

Figure 3 | Evolution of PhD researchers (PhD members and PhD collaborators)

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.

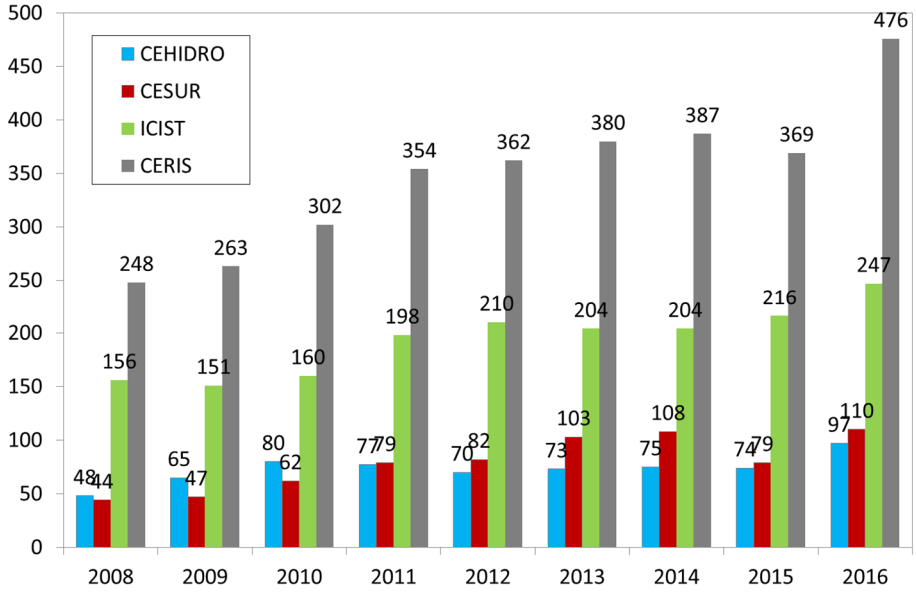

Figure 4 | Evolution of the PhD members and collaborators and PhD students

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 in 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.

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 second 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 2016 show how seriously CERIS was affected by the 2008-2012 evaluation, still in dispute, and by the limitations imposed on the Lisbon region in P2020 calls in terms of research, and by the economic crisis, in terms of consultancy: the budget decreased to 50% of the 2008-2012 average; consultancy funding fell more than 60% and the research funding fell to 65% of the 2008-2012 average. In 2016, 60% of the budget was sourced through research funding and 40% through consultancy funding, against a balanced ratio in 2008-2012 already affected by cuts in competitive public research funding, as a result of an uncharacteristically low year in terms of consultancy.

The results presented in Figure 5, combining research and consultancy funds, reflect the increase in public research funding up to 2009 (CEHIDRO and ICIST) and the initial effects of the economic crisis on specialized consultancy (CESUR). 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 2016 was the worst year in the last decade.

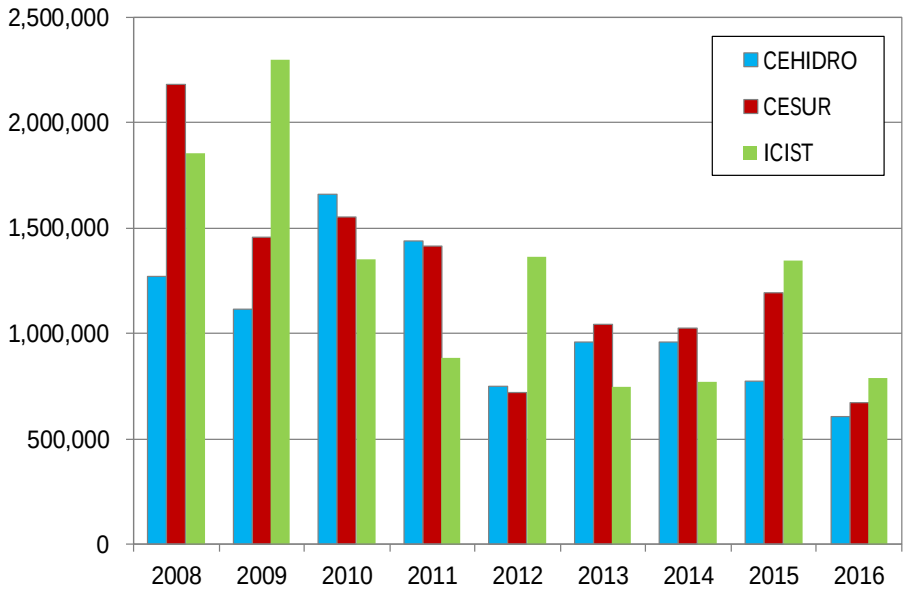

Figure 5 | Total annual funding per research centre (research and consultancy)

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 2014-2016 combine two effects: a stabilization of the economy (with oscillations in 2015 for the best and especially 2016 for the worst) and the research funding losses caused by the last evaluation of CERIS and by the P2020 calls limitations for entities from the Lisbon region. The 2012-2016 funding average is around 40% of the total budget secured in the peak year of 2008. The total value in 2016 (2.1 M€) is the worst in many years, with a massive loss in consultancy and a sizeable decrease in research funding.

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 2016, the average total funding was 9.7 k€ per PhD researcher and 16.6 k€ per PhD member. The capacity of members to secure funding used to support research activities decreased to 30% of the 2008 peak values.

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

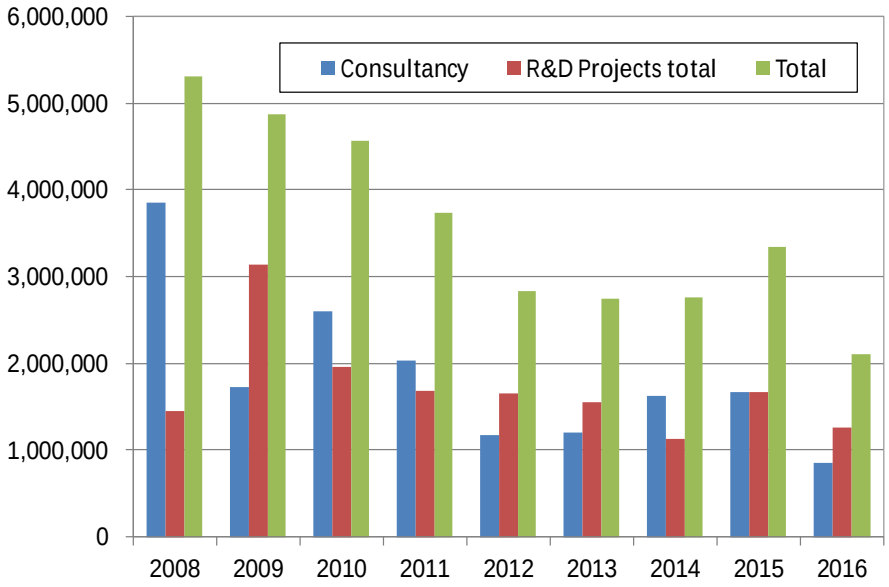

Figure 6 | Annual funding in research and in consultancy

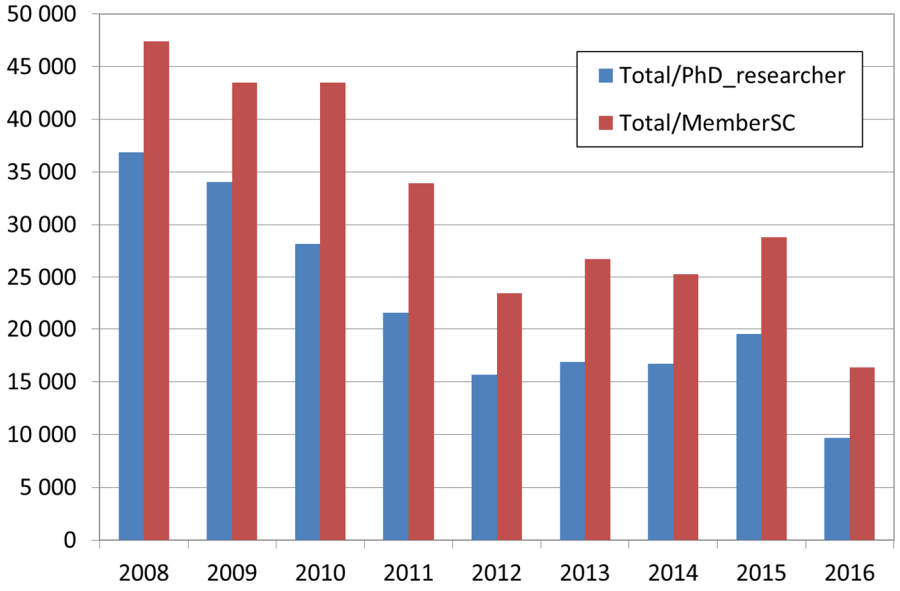

Figure 7 | Total annual funding per PhD researcher and per PhD member

Moreover, the capacity of CERIS to secure research funding weakened in 2014-2016. Nevertheless, Table 18 shows a relatively high success rate in competitive research projects and grants, apparently contradicting the fall registered in the national success rates substantially caused by the cuts introduced in public funding of research. However, namely in terms of national grants, this was an uncharacteristic

year because the publication of the results of some 2014 calls was delayed until mid-2016 and there were hardly any calls in 2016.

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).

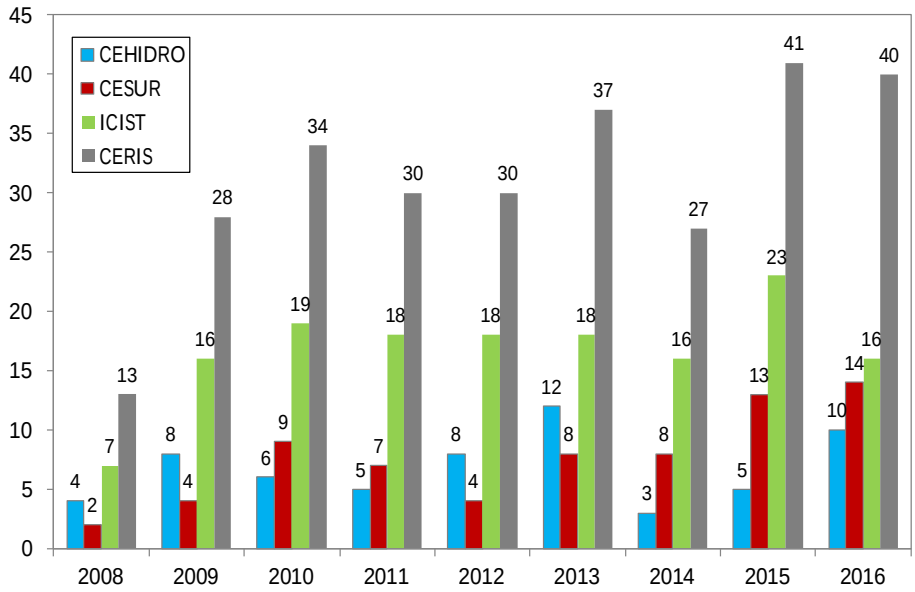

Figure 8 | Concluded PhD theses

In 2016, and as mentioned in Section 2.6, the ratio of PhD students (including CERIS and external students) to PhD members entered the target range in the case of CEHIDRO (3.0) and CESUR (3.1) and is still just reaching the target in ICIST (1.9). Results are expected to improve in 2016-2017 as funding of the structured PhD programs is contracted with FCT until 2021 (Table 152).

Indeed, the success in securing these contracts is the key reason why CERIS sustained the improvement of the main activity indicators under otherwise adverse conditions. CERIS succeeded in coordinating six and participating in one 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 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).

The publication ratios per PhD researcher and per PhD member are presented in Figure 10 and Figure

11, respectively, respectively. The 2016 ratios were 1.2 papers per PhD researcher and 2.1 per PhD member. The patterns are similar for publications in conference proceedings, with 2016 ratios per PhD member of 2.2 and 1.5 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 specially valued in the areas of Architecture and Planning.

As mentioned in Section 2.6, the number and the distribution of PhD students is not directly related with publication rates. ICIST has the lowest rate in PhD students per PhD member and the highest rate in publication in ISI/Scopus journals. Both rates can substantially vary at the group level. It is also noted that publication in Scopus journals is marginal (4% of the total, as shown in Table 163).

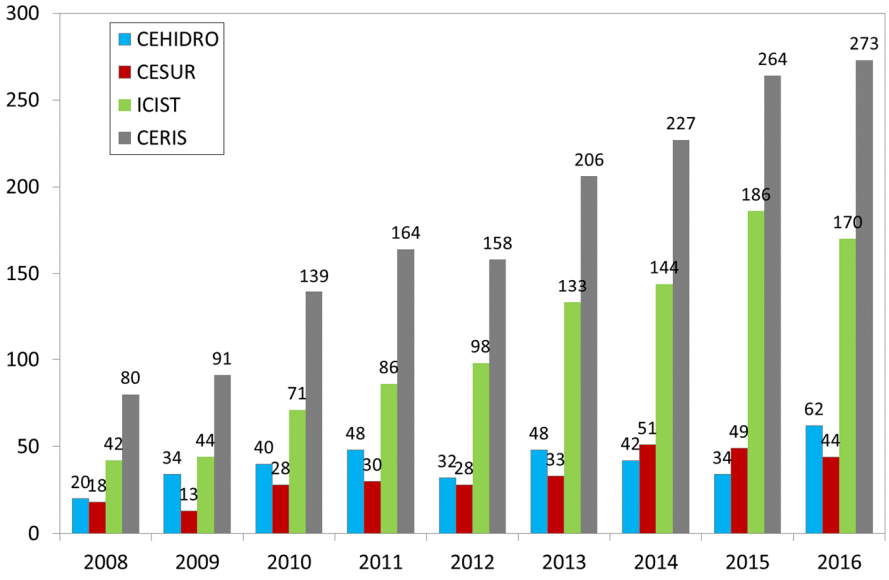

Figure 9 | Papers published in international journals (ISI and Scopus)

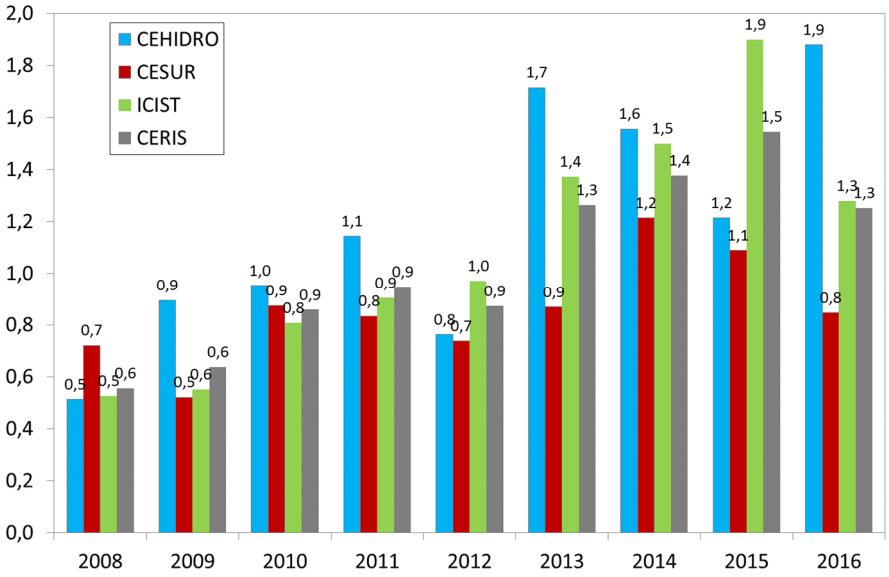

Figure 10 | Publication in ISI/Scopus journals per PhD researcher

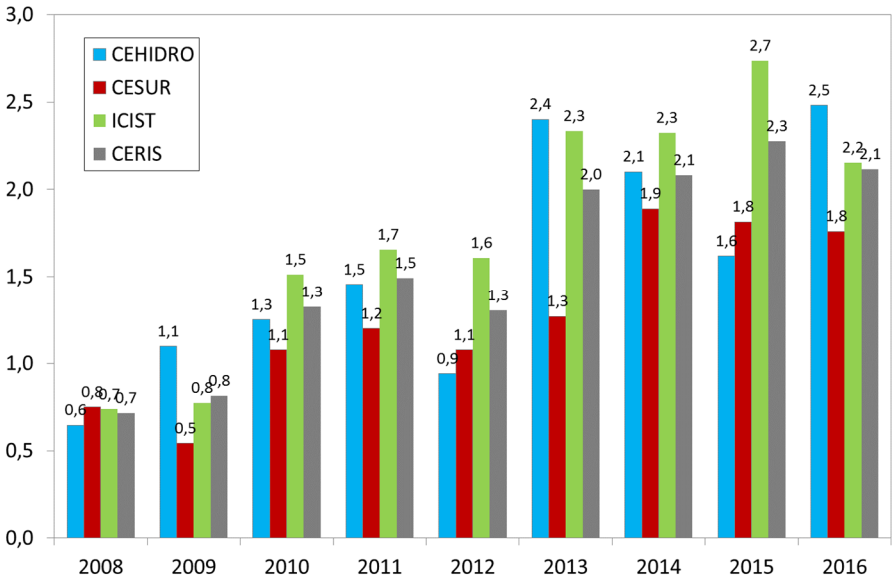

Figure 11 | Publication in ISI/Scopus journals per PhD member

Figure 12 depicts the distribution of the papers published in ISI journals per quartile of impact factor. In the 2013-2016 period, more than 50% of the papers were published in Q1 journals. This number was relatively stable during this period, with a slightly increasing trend. In 2016 this figure was 55%; moreover, 81% of the papers were published in Q1 and Q2 journals, attesting the relatively high average quality of the journal publications of CERIS members.

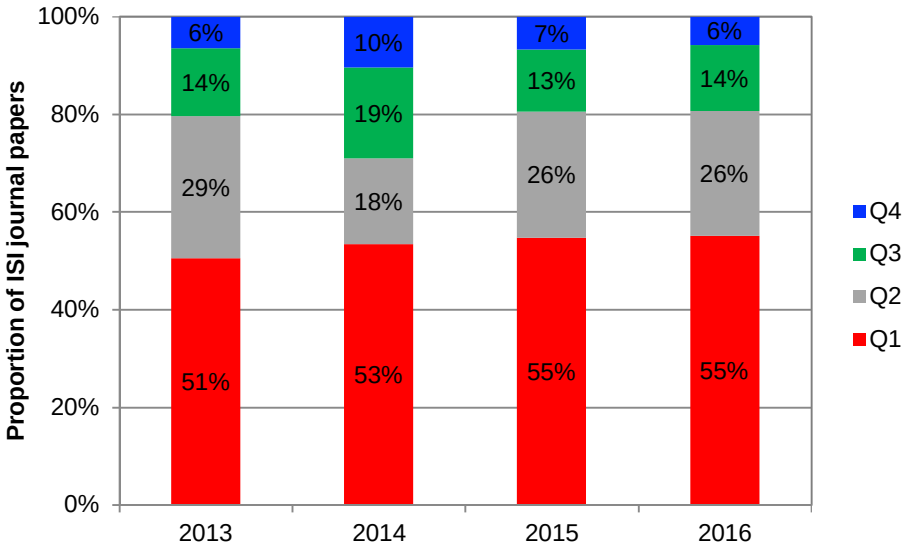

Figure 12 | Distribution of papers published in ISI journals per quartile (Q1 to Q4) of impact factor

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).

RG1 | Architecture

7 PhD members | 11 PhD collaborators | 32/10 PhD students (CERIS-IST/External)

- 3 (39) PhD theses successfully completed (in progress);
- 33 (22) MSc theses successfully completed (in progress);
- 3 papers in ISI journals, 27 (3) communications in international (national) conferences proceedings, 11 book chapters authored and 4 book editions;
- 1 reports related to consultancy projects and industry contract research projects;
- 10 technical-scientific reports resulting from 3 (4) international (national) projects in progress;
- 3 (1) international (national) project grants awarded and 3 other international research grants submitted;
- 5 (1) participations in the editorial boards of international (national) journals;
- 13 collaborations in reviewing papers submitted to international journals[2];
- Participation in the scientific committees of 15 (5) international (national) conferences;
- Participation in 3 national committees responsible for drafting design codes or recommendations;
- Organization of 9 (3) international (national) conferences;
- 6 participations as referees for funding agencies (national and international);
- 3 national and international awards.

RG2 | Earthquake Engineering and Seismology

11 PhD members | 4 PhD collaborators | 13/2 PhD students (CERIS-IST/External)

- 1 (14) PhD theses successfully completed (in progress);
- 17 (8) MSc theses successfully completed (in progress);
- 21 (1) papers in ISI (Scopus) journals, 12 (13) communications in international (national) conferences proceedings, and 3 book chapters authored;
- 6 reports related to consultancy projects and industry contract research projects;
- 5 individual grants awarded;
- 1 Associate Editor of international journals;
- 8 (1) participations in the editorial boards of international (national) journals;
- 37 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 8 (8) international (national) conferences;
- Participation in 4 national committees responsible for drafting design codes or recommendations;

[2] 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).

- Organization of 2 (2) international (national) conferences;
- 6 participations as referees for funding agencies (national and international).

RG3 | Urban and Regional Planning and Environment

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

- 2 (21) PhD theses successfully completed (in progress);
- 20 (39) MSc theses successfully completed (in progress);
- 9 papers in ISI journals, 27 (2) communications in international (national) conferences proceedings, 5 book chapters authored and 2 book editions;
- 10 reports related to consultancy projects and industry contract research projects;
- 4 (1) participations in the editorial boards of international (national) journals;
- 21 (2) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 8 international conferences;
- Organization of 4 (1) international (national) conferences;
- 1 participation as referees for funding agencies (national and international).

RG4 | Environment, Water Resources and Water Services

8 PhD members | 0 PhD collaborators | 26/3 PhD students (CERIS-IST/External)

- 3 (26) PhD theses successfully completed (in progress);
- 20 (18) MSc theses successfully completed (in progress);
- 13 papers in ISI journals, 19 (25) communications in international (national) conferences proceedings and 2 book chapters authored;
- 9 reports related to consultancy projects and industry contract research projects;
- 3 technical-scientific reports;
- 2 international research grants submitted;
- 7 (1) individual grants awarded (submitted);
- 1 Associate Editor of international journal;
- 5 (6) participations in the editorial boards of international (national) journals;
- 35 (5) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 7 (16) international (national) conferences;
- Participation in 5 (1) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 2 (3) international (national) conferences;
- 1 participation as referee for funding agencies (national and international).

RG5 | Hydrogeology and Geo-systems

6 PhD members | 1 PhD collaborator | 2/7 PhD students (CERIS-IST/External)

- 1 (8) PhD theses successfully completed (in progress);

- 2 MSc theses successfully completed;
- 9 (1) papers in ISI (Scopus) journals and 9 communications in international conferences proceedings;
- 1 (2) international (national) project grants awarded and 9 (4) other international (national) research grants submitted;
- 1 individual grant submitted;
- 1 (1) participations in the editorial boards of international (national) journals;
- 18 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 1 (2) international (national) conferences;
- Organization of 1 international conference;
- 5 participations as referees for funding agencies (national and international).

RG6 | Information and Design Support Systems

5 PhD members | 2 PhD collaborators | 6/2 PhD students (CERIS-IST/External)

- 8 PhD theses in progress;
- 26 (15) MSc theses successfully completed (in progress);
- 6 (1) papers in ISI (Scopus) journals, 21 (17) communications in international (national) conferences proceedings and 2 book chapters authored;
- 1 report related to consultancy projects and industry contract research projects;
- 3 national project grants awarded and 1 other international research grants submitted;
- 1 individual grant submitted;
- 1 participation in the editorial boards of international journals;
- 22 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 6 (6) international (national) conferences;
- Participation in 2 (1) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 3 (1) international (national) conferences;
- 1 participation as referees for funding agencies (national and international).

RG7 | Systems and Management

6 PhD members | 8 PhD collaborators | 19/3 PhD students (CERIS-IST/External)

- 19 PhD theses in progress;
- 9 (39) MSc theses successfully completed (in progress);
- 18 papers in ISI journals, 6 (2) communications in international (national) conferences proceedings and 6 book chapters authored;
- 7 reports related to consultancy projects and industry contract research projects;
- 1 (1) international (national) project grants awarded and 1 other national research grant submitted;
- 3 individual grants submitted;
- 1 Editor-in-Chief of international journal;

- 5 participations in the editorial boards of international journals;
- 53 (1) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 5 international conferences;
- Participation in 1 (2) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 7 international conferences;
- 1 participations as referees for funding agencies (national and international).

RG8 | Mechanics, Modelling and Analysis of Structures

13 PhD members | 7 PhD collaborators | 5/5 PhD students (CERIS-IST/External)

- 1 (9) PhD theses successfully completed (in progress);
- 15 (8) MSc theses successfully completed (in progress);
- 29 (2) papers in ISI (Scopus) journals, 25 communications in international conferences proceedings, 1 book chapter and 2 entire books authored, and 1 book edition;
- 1 international project grant awarded;
- 1 Associate Editor of international journal;
- 15 (4) participations in the editorial boards of international (national) journals;
- 30 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 4 international conferences;
- Participation in 5 (2) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 2 international conferences;
- 4 participations as referees for funding agencies (national and international);
- 5 national and international awards.

RG9 | Pressurised, Fluvial and Maritime Hydraulic Systems

11 PhD members | 7 PhD collaborators | 35/2 PhD students (CERIS-IST/External)

- 6 (31) PhD theses successfully completed (in progress);
- 14 (24) MSc theses successfully completed (in progress);
- 38 (1) papers in ISI (Scopus) journals and 35 (17) communications in international (national) conferences proceedings;
- 6 reports related to consultancy projects and industry contract research projects;
- 9 technical-scientific reports resulting from 2 (5) international (national) projects in progress;
- 1 international project grant awarded and 4 (5) other international (national) research grants submitted;
- 10 (1) individual grants awarded (submitted);
- 2 Associate Editors of international journals;
- 6 (2) participations in the editorial boards of international (national) journals;

- 51 (1) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 9 (5) international (national) conferences;
- Organization of 1 national conference;
- 1 national and international award.

RG10 | Structural Design and Geotechnics

9 PhD members | 5 PhD collaborators | 12/1 PhD students (CERIS-IST/External)

- 1 (12) PhD theses successfully completed (in progress);
- 16 (33) MSc theses successfully completed (in progress);
- 11 (1) papers in ISI (Scopus) journals, 11 (17) communications in international (national) conferences proceedings, 2 book chapters and 1 entire book authored;
- 2 reports related to consultancy projects and industry contract research projects;
- 3 technical-scientific reports resulting from 1 national project in progress;
- 2 (2) international (national) project grants awarded and 1 (1) other international (national) research grants submitted;
- 2 individual grants awarded;
- 7 (2) participations in the editorial boards of international (national) journals;
- 24 collaborations in reviewing papers submitted to international journals;
- Participation in the scientific committees of 9 (8) international (national) conferences;
- Participation in 16 (7) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 3 (5) international (national) conferences;
- 2 participations as referees for funding agencies (national and international);
- 1 national and international award.

RG11 | Studies on Construction

26 PhD members | 9 PhD collaborators | 43/10 PhD students (CERIS-IST/External)

- 8 (45) PhD theses successfully completed (in progress);
- 75 (109) MSc theses successfully completed (in progress);
- 76 (3) papers in ISI (Scopus) journals, 60 (42) communications in international (national) conferences proceedings, 5 book chapters and 1 entire book authored;
- 13 reports related to consultancy projects and industry contract research projects;
- 28 technical-scientific reports resulting from 6 (10) international (national) projects in progress;
- 1 (4) international (national) project grants awarded and 14 (9) other international (national) research grants submitted;
- 6 (6) individual grants awarded (submitted);
- 3 Associate Editors and 1 Editor-in-Chief of international journals;
- 31 (7) participations in the editorial boards of international (national) journals;

- 393 (17) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 31 (20) international (national) conferences;
- Participation in 19 (25) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 3 international conferences;
- 18 participations as referees for funding agencies (national and international);
- 7 national and international awards.

RG12 | Transportation Infrastructure, Systems and Policy

10 PhD members | 12 PhD collaborators | 34/8 PhD students (CERIS-IST/External)

- 12 (44) PhD theses successfully completed (in progress);
- 11 (31) MSc theses successfully completed (in progress);
- 22 (1) papers in ISI (Scopus) journals, 24 (29) communications in international (national) conferences proceedings and 2 book chapters authored;
- 6 reports related to consultancy projects and industry contract research projects;
- 8 technical-scientific reports;
- 1 (1) individual grant awarded (submitted);
- 1 Editor-in-Chief of international journals;
- 8 (2) participations in the editorial boards of international (national) journals;
- 8 (2) collaborations in reviewing papers submitted to international (national) journals;
- Participation in the scientific committees of 8 (4) international (national) conferences;
- Organization of 2 national conferences.

RG13 | Structural Design and Geotechnics

8 PhD members | 16 PhD collaborators | 11/10 PhD students (CERIS-IST/External)

- 3 (18) PhD theses successfully completed (in progress);
- 49 (33) MSc theses successfully completed (in progress);
- 22 (2) papers in ISI (Scopus) journals, 27 (40) communications in international (national) conferences proceedings, 1 book chapter and 1 entire book authored;
- 1 technical-scientific reports resulting from 5 national projects in progress;
- 1 international project grant awarded;
- 12 (13) participations in the editorial boards of international (national) journals;
- 36 collaborations in reviewing papers submitted to international (national) journals;
- 3 Associate Editors and 1 Editor-in-Chief of international journals;
- Participation in the scientific committees of 15 (19) international (national) conferences;
- Participation in 24 (19) international (national) committees responsible for drafting design codes or recommendations;
- Organization of 5 international conferences;

- 3 participations as referees for funding agencies (national and international);
- 3 national and international awards.

4 FUTURE RESEARCH

The CERIS activities in 2017 are a natural follow-up of the research carried out in 2016, as summarized in Section 2.4. 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 2.2 and 2.3.

The profiles of the research groups given below refer to 2016. They will change in 2017 in consequence of the CERIS groups reorganization process (Table 11) and adjustments in the number of PhD students. It is reasonable to expect that the students that successfully completed their degrees in 2016 will be replaced by a similar number of doctoral students and that some will remain in CERIS as PhD collaborators. The future activities described of the former groups that have been merged will be developed within the resulting larger new groups.

RG1 | Architecture

7 PhD members | 11 PhD collaborators | 32/10 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG1 Architecture, Urbanism and Territory.

The 2017 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).

RG2 | Earthquake Engineering and Seismology
11 PhD members | 4 PhD collaborators | 13/2 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG7 Structures and Geotechnics.

The programmed activities are set in the framework of the thematic strands on Risk and Safety (TS2) and Rehabilitation (TS3):

- 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.

The main supporting actions planned for 2017 are:

- Coordination and strong integration in the FCT Doctoral Program InfraRisk (Analysis and Mitigation of Risks in Infrastructures, infrarisk.tecnico.ulisboa.pt);
- Development of procedures for the structural/seismic certification of buildings (by means of a FUNDEC course and cooperation with SPES - Portuguese Society for Earthquake Engineering);
- Submission of new bids in national and international research projects (H2020).

RG3 | Urban and Regional Planning and Environment
9 PhD members | 7 PhD collaborators | 7/9 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG1 Architecture, Urbanism and Territory.

The research carried out in 2016 targeting the thematic strands on Risk and Safety (TS2), Rehabilitation (TS3) and Response to changes (TS4) will be extended in 2017. The FCT funded PSSS project is already 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 we be achieved in the scope of on-going PhD and Master Students 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 and in the preparation on the conference in Lisbon at IST in 2017.

In 2017, other events will be organised linked to e-procurement and water governance, the latter in collaboration with the University of Queensland and with the support of the Australian Embassy in Lisbon.

RG4 | Environment, Water Resources and Water Services
8 PhD members | 0 PhD collaborators | 26/3 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG3 Environment and Water Resources.

RG4 will continue to focus the research on the areas of environment, water resources and water services addressed in thematic strands TS2 (Risk and Safety) and TS4 (Response to Societal Changes), with the objective of developing approaches, methodologies and tools that cut across these areas, improving knowledge and capabilities to manage natural and built environments in a sustainable way, increasing productivity indicators of the group and the impact of the internationalization activities of its members. RG4 will concentrate its activities in the following ten 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.

RG5 | Hydrogeology and Geo-systems

6 PhD members | 1 PhD collaborator | 2/7 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG3 Environment and Water Resources.

RG4 will continue the development of advanced and extended groundwater research capacities to bridge the gaps between theory and experimentation, and the use of experience of the members to consolidate and to extend competences in the following major topics addressed in thematic strands TS2 (Risk and Safety), TS3 (Rehabilitation) and TS4 (Response to Changes):

- 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.

RG6 | Information and Design Support Systems

5 PhD members | 2 PhD collaborators | 6/2 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG4 Systems and Management.

The main research scope of the Information and Design Support Systems group concerns the areas of Geographical Information Science and Information and Communication Technologies applied to the Built Environment, focusing in particular Geomatics, Building Information Modelling, and Information Management.

The contribution of the members to thematic strands TS1 (Product Development) and TS3 (Rehabilitation) leads to a more effective sustainability, greater economy and efficiency in construction and focuses on streamlining the process of implementation of the project, based on innovative tools used in the field of Civil Engineering. The activity of the group will be mostly aligned with emergent areas of the H2020 program.

- The Geomatics research main subjects will be particularly focused on disaster-resilience, disaster mapping and management, satellite imagery in the detection and mapping of vertical displacements and natural hazards, interferometry via persistent scatters in the detection and measurement of ground subsidence, ground deformation with advanced SAR methods and 3D virtual city models.
- The focus on Digitalisation and Sustainable Construction is of major importance. In this regard, the Group will particularly focus its effort on BIM, information management and intelligent systems to improve buildings performance within Smart and Digital Built Environments. Improvement of efficiency and effectiveness in urban infrastructure systems is also particularly relevant (e.g. water, wastewater, transport, energy, telecom, etc.), such as the long term sustainable planning of urban infrastructure systems and new governance models.
- As part of the work developed to promote the use of Information and Communication Technologies, the Group will conduct several initiatives regarding e-Learning and the use of information and communication technologies to improve individual and group learning.

RG7 | Systems and Management
6 PhD members | 8 PhD collaborators | 19/3 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG4 Systems and Management.

In line with the activity developed in the previous period, the planned research activities of the group can be placed under three major work areas:

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

Regarding the first work area, the group will be focused on the improvement of the processes and infrastructure projects through the development of better models for project management and the procurement of goods, services and works. Particularly, the group has an extensive work developed in the scope of public-private partnerships arrangements with several models and contributions for the literature and the empirical world. Therefore, in the coming years new solutions will be proposed to achieve higher levels of efficiency and effectiveness of these two activities widely recognized as critical to achieving successful results in infrastructure and other civil engineering areas.

Within the second work area, 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. The group will pursue the development of advanced tools to design and to optimize such complex systems, increasing safety and resilience.

Concerning the third work area, civil engineering has a remarkable tradition of open and comprehensive search for understanding new societal problems, which is very much valued by RG7. Many of these challenges are directly related to the performance of complex organizations serving communities and cities. RG7 will promote the development of: models of complex organizations providing public goods or services, such as water supply, waste schooling, logistics and health networks; 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.

These work areas include the following major topics of thematic strands TS2 (Risk and Safety) and TS4 (Response to Changes):

a) Project management, procurement and contracting

- Risk analysis in Project Management;
- Incentive procurement methods and performance base contracts;
- PPP contract management and monitoring.

b) Improved decision-making and system design, operations and management

- Improved decision making using MCDA methods;
- Systems designs;
- Logistics in construction.

c) Regulatory and pricing policies and system performance assessment

- Incentive regulatory methods;
- Use of benchmarking in regulation;
- Pricing systems for public services;
- Access of vulnerable population to essential services;
- Non-parametric and parametric benchmarking methods;
- Robust non-parametric methods.

RG8 | Mechanics, Modelling and Analysis of Structures
13 PhD members | 7 PhD collaborators | 5/5 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG7 Structures and Geotechnics.

The work of this group will continue to focus mainly on the analysis and design of thin-walled structures and on structural multi-physics problems. The research activity planned for 2017 comprises the following topics and actions:

a) Analysis and design of thin-walled steel structures

- 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.

b) Modelling of nonlinear behaviour

- 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 geomateriais 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.

Further research activity will be devoted to (i) the three-phase modelling of unsaturated structural foundation media, which will be further investigated in cooperation with ISISE researchers from the University of Minho, (ii) the chemo-mechanical modelling of biological porous media and (iii) the modelling of friction in dynamic structural instability. Finally, work will also be developed on the non-smooth dynamic analysis of passive energy dissipation systems and of beams on a foundation under moving vehicles.

The ongoing cooperation with other CERIS research groups and researchers from Portuguese and foreign institutions will continue to be fostered in the framework of thematic strands TS1 (Product Development) and TS3 (Rehabilitation).

RG9 | Pressurised, Fluvial and Maritime Hydraulic Systems
11 PhD members | 7 PhD collaborators | 35/2 PhD students (CERIS-IST/External)

In 2017 this group will be renamed as RG2 Hydraulics.

The programmed research for 2017 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

- Analysis of extreme events near the coast (e.g. freak waves), to improve navigation safety and support the offshore wind energy production industry (moored or floating);
- 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.

RG10 | Structural Design and Geotechnics

9 PhD members | 5 PhD collaborators | 12/1 PhD students (CERIS-IST/External)

In 2017 Group RG10, along with CERIS Groups RG2, RG8 and RG13, will merge into a larger Research Group named "Structures and Geotechnics".

For 2017, it is planned that the members of former RG10 continue working in the same major research lines, namely (1) Steel and Composite Structures (2) Geotechnics and (3) Bridge Design, and deepening the effective collaboration with the other members of the new RG "Structures and Geotechnics", as well as with the other RGs of CERIS, namely by: (i) identifying synergies that can lead to the submission of joint research projects, and by (ii) taking advantage of differences between members expertise and profile.

The main general purpose is to improve the construction sector competitiveness, supporting the development of economical and eco-efficient materials and products, as well as new methodologies to design, build and maintain high-quality and long-lasting structures. This embraces the development of products and design solutions, and the implementation of advanced computational tools for structural assessment and safety verifications (of new and existing structures, and of their foundations).

Other more general objectives of the Group are as follows:

- To participate in national and international standardization committees;
- To participate/organize academic events and national and international conferences;
- To participate in national and international Graduation and Post-Graduation courses (namely FCT Doctoral Programs) in the field of Structures and Geotechnics;
- To perform expert consultancy work to partially fund research and provide practical applications to the results of research;
- To improve the research impact parameters in terms of publication in international referenced journals, books and book chapters, supervision of MSc and PhD Thesis;
- To improve the capacity of attracting competitive funding in national and international research projects calls.

RG11 | Studies on Construction

26 PhD members | 9 PhD collaborators | 43/10 PhD students (CERIS-IST/External)

In 2017 this group will be renamed as RG6 Studies on Construction.

The general objectives of the group for 2017 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 2017 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;

- Building acclimatization and mechanical systems - continue collaboration with the Mechanics and Physics Departments of IST Department of IST, strategically important in terms of sustainable construction in terms of energy-saving; 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.

RG12 | Transportation Infrastructure, Systems and Policy
10 PhD members | 12 PhD collaborators | 34/8 PhD students (CERIS-IST/External)

In 2017 this group will be renamed as RG5 Transportation Systems.

RG12 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 2017 has 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.

RG13 | Structural Design and Geotechnics
8 PhD members | 16 PhD collaborators | 11/10 PhD students (CERIS-IST/External)

In 2017 this group will be integrated in the larger group RG7 Structures and Geotechnics.

The main general purpose of RG13 is to contribute to improve concrete structures in terms of safety, durability, sustainability, and economy, by developing new materials/products, new design/analysis

approaches, new assessment/monitoring methods, and new building/repairing/strengthening techniques. In 2017 the plan is to continue pursuing this goal in the scope of the selected major research topics, namely: (1) Advanced cementitious materials, (2) High-performance ordinary and prestress reinforcement, (3) Enhanced durability, (4) Sustainable and eco-efficient solutions, (5) Modelling and design models (e.g. stress-fields models, FEM-based software with embedded strong discontinuities, concrete reinforced with embedded fibres), (6) Assessment of existing structures (e.g. reliability, structural robustness, monitoring, seismic vulnerability), (7) Structural rehabilitation (e.g. repairing and strengthening techniques, seismic strengthening, passive protection), (8) Prefabrication and innovation.

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.

By joining the expertise of 218 PhD researchers and 302 PhD students (2016), CERIS has 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 year of 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 and developments have shown that were accomplished in 2016.

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 two 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 2016 results show that the economic crisis caused a major drop in the income from specialized consultancy and on-going training as predicted in 2013. The income from research was affected more than what was predicted in 2013 due to the impact of the funding rules for the Lisbon region in P2020 projects and the repercussion of the last evaluation that CERIS finds unjust.

Its effects are already slightly visible in the performance indices registered in 2013-2016 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.

CERIS must regain the leading position in the next evaluation exercise, set for late 2017. The Civil Engineering units best-ranked in 2013 benefitted from a substantial increase in research funding, implying significant improvements in their performance indices in the 2013-2017 evaluation period; moreover, they have very favourable conditions in the Portugal 2020 calls. CERIS had to operate under unfairly adverse conditions when assessing its performance in that period. The implication is that CERIS had to do better in 2013-2017 with much less. It is harder but feasible, if the adjustments in membership and in internal organization necessary to focus the operation on priority research topics and actions are fully implemented.

ANNEX A - PHD THESES COMPLETED IN 2016

A. PhD theses completed

1. Aleksandr Prodan (2016): Infrastructure Access Charges in Vertically-Separated Railway Systems. Contributions to the Development of a Decision Support Model. IST. PhD in Transportation Systems. CERIS Supervisor: Paulo Manuel da Fonseca Teixeira.

2. Ana Sofia Silva Carreira (2016): Transmission of vibration and low frequency sound in reinforcement concrete buildings. IST. PhD in Civil Engineering. CERIS Supervisor: Albano Luís Rebelo da Silva das Neves e Sousa.

3. André Miguel Guimarães dos Santos (2016): Similarities and singularities in the architectural rehabilitation of the school building stock. Faculdade de Arquitetura, Universidade do Porto. PhD in Architecture. CERIS Supervisor: Teresa Valsassina Heitor.

4. André Valente Monteiro (2016): Potential and Actual Durability Related Properties of Concrete. IST. PhD in Civil Engineering. CERIS Supervisor: António José da Silva Costa.

5. Camila Soares Henrique Fontenele Garcia (2016): Strategic Assessment of Accessibility on Urban Mobility Networks. IST. PhD in Transportation Systems. CERIS Supervisor: Maria do Rosário Maurício Ribeiro Macário.

6. Catarina Duarte Prudêncio da Silva (2016): A system for assessing and improving wastewater treatment performance: Energy efficiency and stormwater inflow management. IST. PhD in Environmental Engineering. CERIS Supervisor: José Saldanha Matos.

7. Cláudio Alexandre Pereira Baptista (2016): Multiaxial and variable amplitude fatigue in steel bridges. EPFL. PhD in Civil Engineering. CERIS Supervisor: António José Luís dos Reis.

8. David Ferras Segura (2016): Analysis of Unsteady Skin Friction and Pipe-Wall Rheological Behaviour in Pressurized Transient Flows. IST. PhD in Civil Engineering. CERIS Supervisor: Dídia Isabel Cameira Covas.

9. Dinis Correia Gardete (2016): Contribuição para o Estabelecimento duma Mistura Betuminosa Adequada para o Ciclo de Vida Através da Definição duma Parametrização Eficiente. IST. PhD in Civil Engineering. CERIS Supervisors: Luís Guilherme de Picado Santos; Silvino Dias Capitão.

10. Enio Carlos Mesacasa Júnior (2016): Application of generalized beam theory to semi-rigid plane steel frames. Escola de Engenharia de São Carlos, Universidade de São Paulo. PhD in Structures. CERIS Supervisor: Dinar Zamith Reis Camotim.

11. Francisco Felício Nunes (2016): Structural Behaviour of FRP Pultruded Beams and Columns. IST. PhD in Civil Engineering. CERIS Supervisor: João Pedro Ramôa Ribeiro Correia.

12. Francisco Manuel Bastos Andrade Furtado (2016): Freight Rail Productivity Bottlenecks and Improvements Evaluation on a Network Scale from an Operational Costs Perspective. IST. PhD in Transportation Systems. CERIS Supervisors: José Manuel Caré Baptista Viegas; Paulo Manuel da Fonseca Teixeira.

13. Francisco Vitor Mota Sá (2016): Seismic Risk - New Instruments for Analysis and Communication. IST. PhD in Civil Engineering. CERIS Supervisors: Carlos Alberto Ferreira de Sousa Oliveira; Mário Manuel Paisana dos Santos Lopes.

14. Gonçalo Gonçalves Duarte Santos (2016): One-Way Carsharing Systems: Real-Time Optimization of Staff Movements and Operations. IST. PhD in Transportation Systems. CERIS Supervisor: José Manuel Caré Baptista Viegas.

15. Heather Luclaire Jones (2016): Transportation Infrastructure Project Evaluation: Transforming CBA to Include a More Encompassing Life Cycle Perspective. IST. PhD in Transportation Systems. CERIS Supervisor: Filipe Manuel Mercier Vilaça e Moura.

16. Henrique Manuel Borges Miranda (2016): Misturas Betuminosas de Alto Desempenho do Tipo Stone Mastic Asphalt - Formulação, Fabrico, Aplicação e Desempenho. IST. PhD in Civil Engineering. CERIS Supervisor: José Neves.

17. Irene Almeida Samora (2016): Hydropower and Energy Efficiency in Water Systems. IST. PhD in Civil Engineering. CERIS Supervisor: Helena Margarida Machado da Silva Ramos.

18. João Pedro Faria Feliciano (2016): Infrastructure Asset Management in Urban Water Utilities - Knowledge Creation Through the Implementation of Combined Methodologies. IST. PhD in Civil Engineering. CERIS Supervisor: Dídia Isabel Cameira Covas.

19. Joaquim Pedro Alegre Mendes (2016): Meanings in health professionals in gender violence. Univ. Évora. PhD in Human Ecology. CERIS Supervisor: Fátima Bernardo.

20. Luciana Rocha (2016): Intervention in Modern Architecture: knowledge, characterization and safekeeping of residential buildings. FAUP. PhD in Architecture. CERIS Supervisor: Ana Tostões.

21. Luís Filipe Esteves Caetano (2016): Optimization of Railway Track Maintenance and Renewal Operations. IST. PhD in Transportation Systems. CERIS Supervisor: Paulo Manuel da Fonseca Teixeira.

22. Luís Guilherme da Cunha Seixas Valarinho (2016): Construction in Structural Glass. Flexural Behaviour of Laminated Glass Members and Development of Glass-GFRP Composite Beams. IST. PhD in Civil Engineering. CERIS Supervisor: João Pedro Ramôa Ribeiro Correia; Fernando António Baptista Branco.

23. Luís Manuel Jorge Morgado (2016): Timber Housing in Portugal - Methodology to Support the Architecture Project. IST. PhD in Architecture. CERIS Supervisors: Manuel de Arriaga Brito Correia Guedes; João Gomes Ferreira.

24. Maria João Pereira Monteiro Gomes Mendes Ferreira (2016): The walking city. The act of walking and the perception of the walking city. FCSH/Univ. Nova de Lisboa / ISCTE-IU. PhD in Urban Studies. CERIS Supervisor: Fátima Bernardo.

25. Maria Spandou (2016): Framework for the Assessment of Institutional Design of Metropolitan Public Transport Systems. IST. PhD in Transportation Systems. CERIS Supervisor: Maria do Rosário Maurício Ribeiro Macário.

26. Maria Teresa de Almeida Gouveia Geraldes Freire (2016): Restoration of Ancient Portuguese Interior Plaster Coatings: Characterization and Development of Compatible Gypsum-Based Products. IST. PhD in Civil Engineering. CERIS Supervisor: Jorge Manuel Caliço Lopes de Brito.

27. Mário Alexandre de Jesus Garrido (2016): Rehabilitation of Building Floors with Lightweight High Performance GFRP Sandwich Panels. IST. PhD in Civil Engineering. CERIS Supervisors: João Pedro Ramôa Ribeiro Correia; Fernando António Baptista Branco.

28. Micael Manuel Gonçalves Inácio (2016): Punching Shear Behaviour of High Strength Concrete Flat Slabs. FCT/UNL. PhD in Civil Engineering. CERIS Supervisors: António Manuel Pinho Ramos; Válter José da Guia Lúcio.

29. Miguel Nuno Caneiras Bravo (2016): Mechanical and durability performance of concrete made with fine recycled aggregates from Construction and demolition waste from Portuguese recycling plants. IST. PhD in Civil Engineering. CERIS Supervisor: Jorge Manuel Caliço Lopes de Brito.

30. Mohammad Javad Ostad Mirza (2016): Experimental study on the influence of abrupt slope changes on flow characteristics over stepped spillways. IST/EPFL. PhD in Civil Engineering. CERIS Supervisor: Jorge Saldanha Matos.

31. Natércia Mendes Matias (2016): Release of hydrogen sulfide and other volatile compounds in sewer systems under turbulent conditions. IST. PhD in Environmental Engineering. CERIS Supervisor: Filipa Ferreira.

32. Nuno Miguel da Conceição Martins (2016): Transient flow dynamics in pressurized pipes: CFD modelling and experimental analysis. IST. PhD in Civil Engineering. CERIS Supervisors: Dídia Isabel Cameira Covas; Helena Margarida Machado da Silva Ramos.

33. Nuno Ricardo Costa Marujo da Silva (2016): Development of a System for Life-Cycle Management of Maritime Works - SIMOM. The Case of Rubble-Mound Breakwaters. IST. PhD in Civil Engineering. CERIS Supervisor: António Alexandre Trigo Teixeira.

34. Patrícia Carlota Costa Escórcio (2016): Experimental and Analytical Study of Concrete Structures Reinforced With GFRP Bars. Univ. Madeira. PhD in Civil Engineering. CERIS Supervisor: Paulo Miguel Macedo França.

35. Pedro Miguel Guerra Domingos (2016): Modelação do Comportamento de Pavimentos Rodoviários Flexíveis através de Métodos Incrementais - Contributo para Melhoria dos Métodos de Dimensionamento. IST. PhD in Transportation Systems. CERIS Supervisor: José Manuel Coelho das Neves.

36. Rita Maria Vilela Nogueira (2016): Lime Plasters and Renders. Characterization and Assessment of Consolidation Treatments. IST. PhD in Civil Engineering. CERIS Supervisors: Ana Paula Patrício Teixeira Ferreira Pinto França de Santana; Augusto Martins Gomes.

37. Sandra Maria Marques de Miranda Pombo (2016): Hydrological modelling under scarcity conditions of data to evaluate water availability. The case of Angola. IST. PhD in Civil Engineering. CERIS Supervisor: Rodrigo de Almada Cardoso Proença de Oliveira.

38. Sofia Kalakou (2016): Bringing New Elements to Airport Terminal Planning and Operation: A Pedestrian Behavior and Technology-Oriented Approach. IST. PhD in Transportation Systems. CERIS Supervisor: Filipe Manuel Mercier Vilaça e Moura.

39. Vítor Manuel da Cruz Oliveira (2016): Gestão e Controlo de Qualidade em InfraEstruturas Rodoviárias: Uma Aplicação à Drenagem. IST. PhD in Civil Engineering. CERIS Supervisor: José Manuel Caré Baptista Viegas.

40. Zélia Chrispim (2016): Hydrochemical and vulnerability characterization of the main groundwater bodies in the Campos Basin, Rio de Janeiro, Brazil. UENF. PhD in Civil Engineering. CERIS Supervisor: Maria Teresa Condesso de Melo.

ANNEX B - PAPERS PUBLISHED IN ISI/SCOPUS JOURNALS IN 2016

B.1. Papers in ISI journals

1. Ahani, P.; Arantes, A.; Melo, S. (2016): "A portfolio approach for optimal fleet replacement toward sustainable urban freight transportation", Transportation Research Part D: Transport and Environment, V. 48, 357-368, October 2016. DOI:10.1016/j.trd.2016.08.019

2. Akhmouch, A.; Correia, F.N. (2016): "The 12 OECD principles on water governance – When science meets policy", Utilities Policy, V. 43, Part A, 14-20, December 2016. DOI:10.1016/j.jup.2016.06.004

3. Alegre, H.; Coelho, S.T.; Vitorino, D.; Covas, D.I.C. (2016): "Infrastructure asset management – the TRUST approach and professional tools", Water Science and Technology: Water Supply, V. 16, n.º 4, 1122-1131, August 2016. DOI:10.2166/ws.2016.033

4. Allard, R.F.; Moura, F. (2016): "The Incorporation of Passenger Connectivity and Intermodal Considerations in Intercity Transport Planning", Transport Reviews, V. 36, n.º 2, 251-277, 2016. DOI:10.1080/01441647.2015.1059379

5. Almeida, A.; Inácio, M.; Lúcio, V.; Ramos, A.P. (2016): "Punching behaviour of RC flat slabs under reversed horizontal cyclic loading", Engineering Structures, V. 117, 204-219, June 2016. DOI:10.1016/j.engstruct.2016.03.007

6. Almeida, G.; Melício, F.; Biscaia, H.; Chastre, C.; Fonseca, J.M. (2016): "In-plane displacement and strain image analysis", Computer-Aided Civil and Infrastructure Engineering, V. 31, n.º 4, 292-304, April 2016. DOI:10.1111/mice.12127

7. Almeida, M.; Loupa-Ramos, I.; Menezes, H.; Carvalho-Ribeiro, S.; Guiomar, N.; Pinto-Correia, T. (2016): "Urban population looking for rural landscapes: Different appreciation patterns identified in Southern Europe", Land Use Policy, V. 53, 44-55, May 2016. DOI:10.1016/j.landusepol.2015.09.025

8. Amado, M.; Poggi, F.; Amado, A.R. (2016): "Energy efficient city: A model for urban planning", Sustainable Cities and Society, V. 26, 476-485, October 2016. DOI:10.1016/j.scs.2016.04.011

9. Amado, M.; Ramalhete, I; Amado, A.; Freitas, J. (2016): "Regeneration of informal areas: An integrated approach", Cities, V. 58, 59-69, October 2016. DOI:10.1016/j.cities.2016.05.015

10. Amani, J.; Oterkus, E.; Areias, P.; Zi, G.; Nguyen-Thoi, T.; Rabczuk, T. (2016): "A non-ordinary state-based peridynamics formulation for thermoplastic fracture", International Journal of Impact Engineering, V. 87, 83-94, January 2016. DOI:10.1016/j.ijimpeng.2015.06.019

11. Amaral, R.; Alegre, H.; Matos, J.S. (2016): "A service-oriented approach to assessing the infrastructure value index", Water Science and Technology, V. 74, n.º 2, 542-548, July 2016. DOI:10.2166/wst.2016.250

12. Andersson, L.-E.; Pinto da Costa, A.; Agwa, M.A. (2016): "Existence and uniqueness for frictional incremental and rate problems – sharp critical bounds", ZAMM - Journal of Applied Mathematics and Mechanics, V. 96, n.º 1, 78-105, January 2016. DOI:10.1002/zamm.201400143

13. Andrade, A.R.; Teixeira, P.F. (2016): "Exploring Different Alert Limit Strategies in the Maintenance of Railway Track Geometry", Journal of Transportation Engineering, Part A: Systems, V. 142, n.º 9, art. 04016037, September 2016. DOI:10.1061/(ASCE)TE.1943-5436.0000867

14. Antunes, M.D.; Marecos, V.; Neves, J.; Morgado, J. (2016): "Decision to paving solutions in road infrastructures based on life-cycle assessment", Baltic Journal of Road and Bridge Engineering, V. 11, n.º 1, 43-52, 2016. DOI:10.3846/bjrbe.2016.05

15. Antunes, V.; Freire, A.C.; Quaresma, L.; Micaelo, R. (2016): "Effect of the chemical composition of fillers in the filler–bitumen interaction", Construction and Building Materials, V. 104, 85-91, February 2016. DOI:10.1016/j.conbuildmat.2015.12.042

16. Araújo, M.A.V.C.; Pestana, R.; Matias, M.; Roque, D.; Trigo-Teixeira, A.; Heleno, S. (2016): "Using simplified bathymetry and SAR imagery in the validation of a hydraulic model for the Tagus River floodplain", Journal of Coastal Research, V. 75, 13-17, March 2016. DOI:10.2112/SI75-003.1

17. Areias, P.; Mota Soares, C.A.; Rabczuk, T. (2016): "Least-squares finite strain hexahedral element/constitutive coupling based on parametrized configurations and the Löwdin frame", Finite Elements in Analysis and Design, V. 108, 96-109, January 2016. DOI:10.1016/j.finel.2015.09.010

18. Areias, P.; Mota Soares, C.A.; Rabczuk, T.; Garção, J. (2016): "A finite-strain solid–shell using local Löwdin frames and least-squares strains", Computer Methods in Applied Mechanics and Engineering, V. 311, 112-133, November 2016. DOI:10.1016/j.cma.2016.07.044

19. Areias, P.; Msekh, M.A.; Rabczuk, T. (2016): "Damage and fracture algorithm using the screened Poisson equation and local remeshing", Engineering Fracture Mechanics, V. 158, 116-143, June 2016. DOI:10.1016/j.engfracmech.2015.10.042

20. Areias, P.; Rabczuk, T.; Camanho, P.P. (2016): "Finite-strain laminates: Bending-enhanced hexahedron and delamination", Composite Structures, V. 139, 277-290, April 2016. DOI:10.1016/j.compstruct.2015.12.007

21. Areias, P.; Rabczuk, T.; César de Sá, J. (2016): "A novel two-stage discrete crack method based on the screened Poisson equation and local mesh refinement", Computational Mechanics, V, 58, n.º 6, 1003-1018, December 2016. DOI:10.1007/s00466-016-1328-5

22. Areias, P.; Rabczuk, T.; César de Sá, J.; Alves, J.L. (2016): "Semi-implicit finite strain constitutive integration and mixed strain/stress control based on intermediate configurations", Engineering Structures, V. 124, 344-360, October 2016. DOI:10.1016/j.engstruct.2016.06.035

23. Areias, P.; Rabczuk, T.; Msekh, M.A. (2016): "Phase-field analysis of finite-strain plates and shells including element subdivision", Computer Methods in Applied Mechanics and Engineering, V. 312, 322-350, December 2016. DOI:10.1016/j.cma.2016.01.020

24. Areias, P.; Samaniego, E.; Rabczuk, T. (2016): "A staggered approach for the coupling of Cahn–Hilliard type diffusion and finite strain elasticity", Computational Mechanics, V. 57, n.º 2, 339-351, February 2016. DOI:10.1007/s00466-015-1235-1

25. Arruda, M.R.T.; Firmo, J.P.; Correia, J.R.; Tiago, C. (2016): "Numerical modelling of the bond between concrete and CFRP laminates at elevated temperatures", Engineering Structures, V. 110, 233-243, March 2016. DOI:10.1016/j.engstruct.2015.11.036

26. Barrelas, J.; Brito, J. de; Correia, J.R. (2016): "Analysis of the degradation condition of secondary schools. case study: pavilions and prefabricated buildings", Journal of Civil Engineering and Management, V. 22, n.º 6, 768-779, 2016. DOI:10.3846/13923730.2014.914090

27. Belejo, A.; Bento, R. (2016): "Improved Modal Pushover Analysis in seismic assessment of asymmetric plan buildings under the influence of one and two horizontal components of ground motions", Soil Dynamics and Earthquake Engineering, V. 87, 1-15, August 2016. DOI:10.1016/j.soildyn.2016.04.011

28. Beltrán, M.G.; Barbudo, A.; Agrela, F.; Jiménez, J.R.; Brito, J. de (2016): "Mechanical performance of bedding mortars made with olive biomass bottom ash", Construction and Building Materials, V. 112, 699-707, June 2016. DOI:10.1016/j.conbuildmat.2016.02.065

29. Berbellini, A.; Morelli, A.; Ferreira, A.M.G. (2016): "Ellipticity of Rayleigh waves in basin and hard-rock sites in Northern Italy", Geophysical Journal International, V. 206, n.º 1, 395-407, July 2016. DOI:10.1093/gji/ggw159

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31. Bernardo, F.; Palma-Oliveira, J.M. (2016): "Urban neighbourhoods and intergroup relations: The importance of place identity", Journal of Environmental Psychology, V. 45, 239-251, March 2016. DOI:10.1016/j.jenvp.2016.01.010

32. Bernardo, M.; Gomes, M.C.; Brito, J. de (2016): "Demolition waste generation for development of a regional management chain model", Waste Management, V. 49, 156-169, March 2016. DOI:10.1016/j.wasman.2015.12.027

33. Bernhardsdóttir, Á.E.; Musacchio, G.; Ferreira, M.A.; Falsaperla, S. (2016): "Informal education for disaster risk reduction", Bulletin of Earthquake Engineering, V. 14, n.º 7, 2105-2116, July 2016. DOI:10.1007/s10518-015-9771-9

34. Besharat, M.; Tarinejad, R.; Aalami, M.T.; Ramos, H.M. (2016): "Study of a compressed air vessel for controlling the pressure surge in water networks: CFD and experimental analysis", Water Resources Management, V. 30, n.º 8, 2687-2702, June 2016. DOI:10.1007/s11269-016-1310-1

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36. Biscaia, H.C.; Borba, I.S.; Silva, C.; Chastre, C. (2016): "A nonlinear analytical model to predict the full-range debonding process of FRP-to-parent material interfaces free of any mechanical anchorage devices", Composite Structures, V. 138, 52-63, March 2016. DOI:10.1016/j.compstruct.2015.11.035

37. Biscaia, H.C.; Chastre, C.; Borba, I.S.; Silva, C. (2016): "Experimental evaluation of bonding between CFRP laminates and different structural materials", Journal of Composites for Construction, V. 20, n.º 3, , June 2016. DOI:10.1061/(ASCE)CC.1943-5614.0000631

38. Biscaia, H.C.; Cruz, D.; Chastre, C. (2016): "Analysis of the debonding process of CFRP-to-timber interfaces", Construction and Building Materials, V. 113, 96-112, June 2016. DOI:10.1016/j.conbuildmat.2016.03.033

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40. Bogas, J.A.; Brito, J. de; Ramos, D. (2016): "Freeze-thaw resistance of concrete produced with fine recycled concrete aggregates", Journal of Cleaner Production, V. 115, 294-306, March 2016. DOI:10.1016/j.jclepro.2015.12.065

41. Bogas, J.A.; Real, S.; Ferrer, B. (2016): "Biphasic carbonation behaviour of structural lightweight aggregate concrete produced with different types of binder", Cement and Concrete Composites, V. 71, 110-121, August 2016. DOI:10.1016/j.cemconcomp.2016.05.006

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monthly and seasonal operation", Journal of Water Supply: Research and Technology-Aqua, V. 65, n.º 8, 612-625, December 2016. DOI:10.2166/aqua.2016.020

50. Caetano, L.F.; Teixeira, P.F. (2016): "Predictive maintenance model for ballast tamping", Journal of Transportation Engineering, V. 142, n.º 4, art. 04016006, April 2016. DOI:10.1061/(ASCE)TE.1943-5436.0000825

51. Caetano, L.F.; Teixeira, P.F. (2016): "Strategic model to optimize railway-track renewal operations at a network level", Journal of Infrastructure Systems, V. 22, n.º 2, June 2016. DOI:10.1061/(ASCE)IS.1943-555X.0000292

52. Çaktı, E.; Saygılı, Ö.; Lemos, J.V.; Oliveira, C.S. (2016): "Discrete element modeling of a scaled masonry structure and its validation", Engineering Structures, V. 126, 224-236, November 2016. DOI:10.1016/j.engstruct.2016.07.044

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