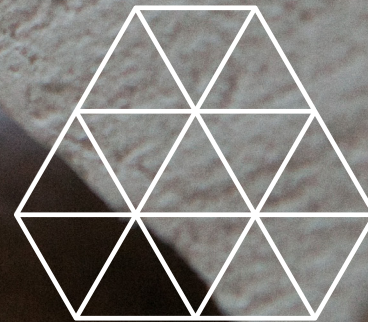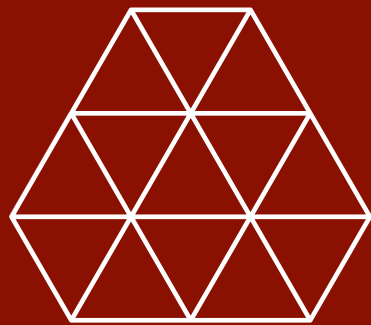# CONSTRUCT R&D REPORT 2018—2023

GENERAL OVERVIEW

GENERAL OVERVIEW

The Institute of R&D in Structures and Construction, CONSTRUCT, was created in 2015, stemming from the merging of two previous research units settled at the Civil Engineering Department of FEUP. CONSTRUCT was ranked as "Exceptional" and "Very Good" in the two last Scientific Evaluation processes of R&D Units of FCT.

CONSTRUCT is hosted by FEUP, the largest faculty of the University of Porto and the oldest school of civil engineers in Portugal, founded in 1837 with the name of Academia Polytechnica, currently offering Bachelor, Master and Doctoral Programs in Civil Engineering.

The R&D activities of CONSTRUCT have been developed on three main focus areas in line with the main pillars of the European Construction Technology Platform - SUSTAINABLE CONSTRUCTION, BUILDINGS and INFRASTRUCTURES - and have been organized in the following six thematic lines (TLs) in the period 2018-2023:

TL1- New construction materials. Recycling and valorization

TL2 - Built historical heritage. Preservation, natural actions and climate change

TL3 - Safety assessment and seismic engineering. Modelling and testing

TL4 – Assessment and SHM of energy and transportation infrastructures

TL5 - Railway infrastructures

TL6 - Efficient and Smart Construction

In that period, CONSTRUCT was constituted by six research groups, with a total average number of PhD integrated members of 53 *(collaborating with about 20 post-doc researchers and 60 PhD students)*, contributing to the six thematic lines according to a matrix organization and using well-equipped laboratories, with an overall area exceeding 3500m2.

Important drivers of CONSTRUCT research have been:
· Contribute to a people-centric, climate-neutral, sustainable, resilient and smart built environment
· Strengthen international collaboration and participation in consortia at the EU level
· Develop expertise to improve the competitiveness of Portuguese Civil Engineering design and construction companies
· Strengthen diversified and life-long relationships with the Society, namely with government, municipalities, public and private companies, contractors and consultancy offices.

In the period 2018-2023, CONSTRUCT researchers had a significant increase in relevant scientific outcomes concerning the previous period of evaluation (2013-2017), with the annual average number of papers published in ISI journals increasing from 89 to **149** (about **2,8** ISI journal papers / PhD year) *(Figure 1)*.
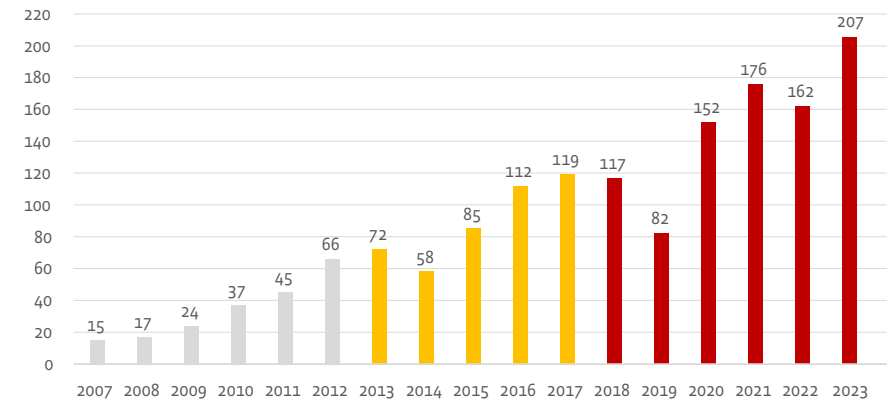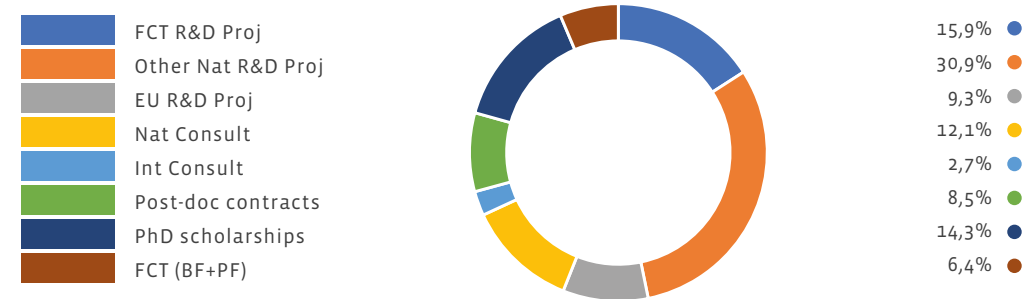
INTERNATIONAL JOURNALS · ISI

Figure 1 · Evolution of the number of papers published in international ISI journals per year

Moreover, **78** R&D projects were obtained under competitive calls at the national or European level, **101** relevant consultancy contracts were established with the Industry, **490** Master Theses and **79** PhD Theses have been concluded, **1067** international papers were published (**896** ISI papers), and about **50** international conferences have been organized by CONSTRUCT researchers. The average annual budget achieved (excluding permanent staff) was about **3,6 M€**, with the average percentual distribution of funding sources indicated in *Figure 2*.
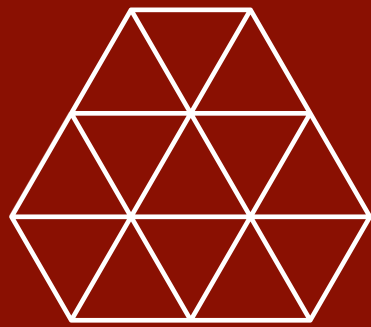
CONSTRUCT Funding Sources

FCT R&D Proj	15,9%
Other Nat R&D Proj	30,9%
EU R&D Proj	9,3%
Nat Consult	12,1%
Int Consult	2,7%
Post-doc contracts	8,5%
PhD scholarships	14,3%
FCT (BF+PF)	6,4%

ercentual distribution of the total budget of CONSTRUCT by the several sources of funding

This progress (in quantity and also in quality) derived, in particular, from the following factors: (i) high proactivity in terms of launching new R&D Project proposals and exploring different sources of national and European funding, increasing the total budget of the Unit over **55%** with regard to the previous period of evaluation (ii) significant increase of contracts with post-doc researchers, whose participation became of utmost importance for CONSTRUCT; (iii) reinforcement of consistency into focused TLs, encouraging inter-group work; (iv) increase of experimental research taking maximum profit from the excellent FEUP campus infrastructures; (v) improvement of internal procedures for evaluation of the individual scientific productivity.

The good performance of CONSTRUCT contributes to the position of UPorto in the international rankings by subject, which are based on research outcomes, such as the ARWU Shanghai, QS and NTU rankings, where the Civil Engineering subject at UPorto is typically ranked in the top **100** worldwide.

R&D
PROJECTS

UHPGRADE — Next generation of ultra-high performance fibre-reinforced cement based composites for rehabilitation and strengthening of the existing infrastructure

The maintenance of the existing infrastructure is becoming a heavy burden for society. The funding required for the rehabilitation, strengthening or replacement of deteriorated structures is very significant and, in the Portuguese case, is expected to increase in the next decades. The energy consumption and CO_2 emissions from construction sites, as well as the indirect user costs related to the service disruptions, contribute to the total costs. In the future, sustainable structures will be those requiring just minimum preventive maintenance with no or little service disruptions. Research should focus on developing technologies to improve the existing structures and limiting the construction interventions to a strict minimum while providing long and safe service duration. The use of thin Ultra-High Performance Fibre-Reinforced cement-based Composites (UHPFRC) layers for rehabilitation and strengthening of concrete structures has shown to be a promising technique towards this objective. Due to its outstanding properties, not only the structure can be strengthened, but also the durability can be improved due to its extremely low permeability. Moreover, its compatibility with concrete and tailored rheological properties allow for efficient and short-duration interventions. The first objective of this proposal is the development of a second generation of UHPFRC, more eco-efficient by achieving target mechanical and transport properties with reduced cement content and

incorporating spent equilibrium catalyst (ECat), a residue generated by the Portuguese oil refinery industry. Besides exploring its pozzolanic activity, Ecat is going to be used for reducing the strong autogenous shrinkage of UHPFRC, which is an important improvement when the application of this material in thin layers over hardened concrete substrates is envisaged. The second objective of this research is a methodology for predicting the tensile response of UHPFRC, which is critical for the strengthening and waterproofing efficiency and depends on the fibre content and orientation. As these may vary throughout the structure and differ from standard test specimens, the tensile response of UHPFRC cannot be intrinsically defined. A non-destructive test (NDT) based on the magnetic properties of steel fibres will be developed for in-situ characterization of the fibre content and orientation in UHPFRC layers. Using the NDT information and knowledge about fibre debonding/pull-out mechanics, the directionally dependent; tensile response of UHPFRC will be obtained. The outcomes of this project are expected to significantly improve the scientific knowledge about the mechanical and durability performance of UHPFRC, thus contributing to its acceptance by the technical community. The project counts with a multidisciplinary team, with domains of expertise covering structural engineering, material science and electromagnetism.
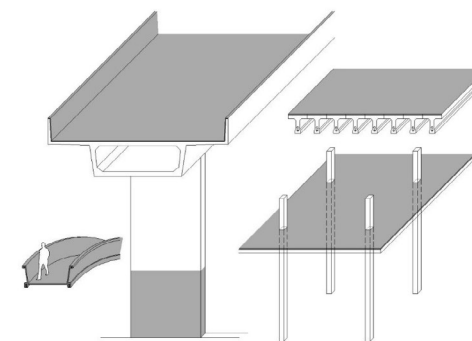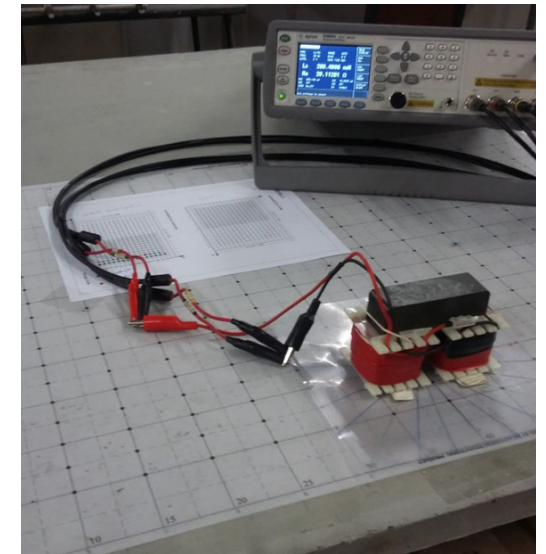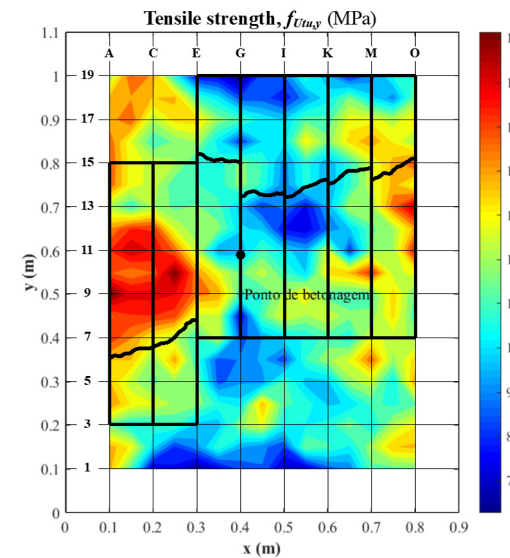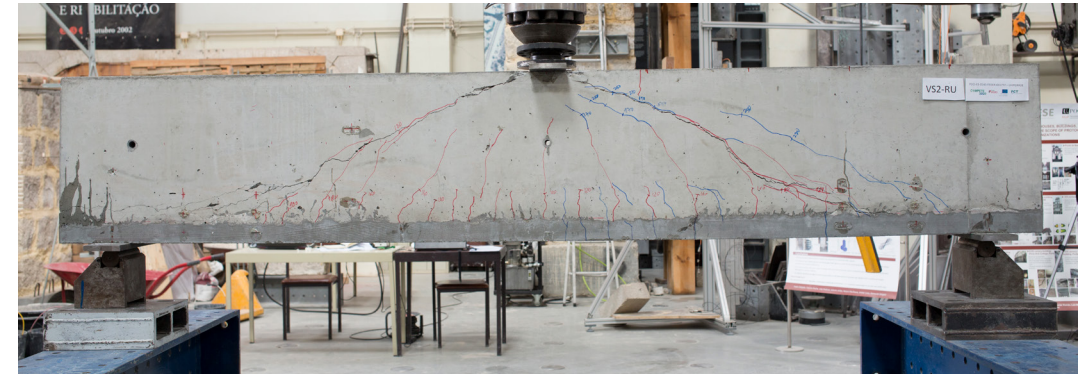
Applications of UHPFRC
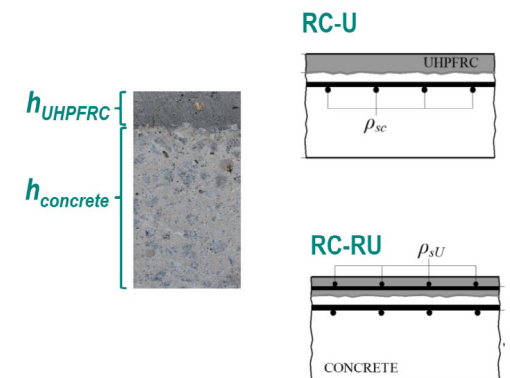
Concept for strengthening and rehabilitation

IntegraCrete — A comprehensive multi-physics and multi-scale approach to the combined effects of applied loads and thermal/shrinkage deformations in reinforced concrete structures

Reinforced concrete (RC) is one of the most used materials in construction, but although there are adequate models for designing and predicting the ultimate capacity of RC structures, the prediction of performance under service conditions has not yet reached the desirable maturity. This often leads to inappropriate behaviour of RC structures under service load conditions, even when the regulatory provisions are carefully followed. These deficiencies are felt by society through the appearance of cracks with large openings (>0.3mm), which cause drastic reductions in the lifetime of RC structures, or require costly repair operations. After an initial dormant period, the mechanical properties of the concrete significantly evolve towards their final values throughout the cement hydration process. As this hydration reaction is highly exothermic, important temperature variations, and consequently volumetric deformations, are induced in the RC structures. Additionally, the internal consumption of water motivated by the cement hydration, together with the progressive drying associated with the evaporation of water, lead to desiccation of the porous concrete structure, resulting in the material's volumetric shrinkage. Any restriction to these deformations causes tensile stresses. Along with the aforementioned phenomena, RC structures are naturally subjected to their self-weight, and support external loads. The most important challenge in predicting the RC behaviour under service load conditions lies in the adequate description of the complex interactions that exist between the imposed deformations (thermal and shrinkage), the concrete creep and the effects of the external loads applied in the crack opening and its progression process. These interactions are not taken into account in current regulatory approaches, and there is no integrated scientific work that systematically addresses this problem. This project aims to fill this research gap, through a comprehensive program that incorporates experimental characterization, real-scale testing with monitoring, and the corresponding simulation using multi-scale and multi-physics models. The central innovation of this project lies in the combination of the research team capabilities, with knowledge and scientific experience in the experimental and advanced numerical simulation tasks, opening the way for integrated innovations from micro-structural characterization and modelling, until testing, simulation and validation of real scale RC structures. Improved predictions of concrete cracking will have significant impacts on the design of new structures, and strengthening of existing ones, which will perform better in service than today, and therefore with longer life without maintenance.

172 days   78 h   17 h   8 h
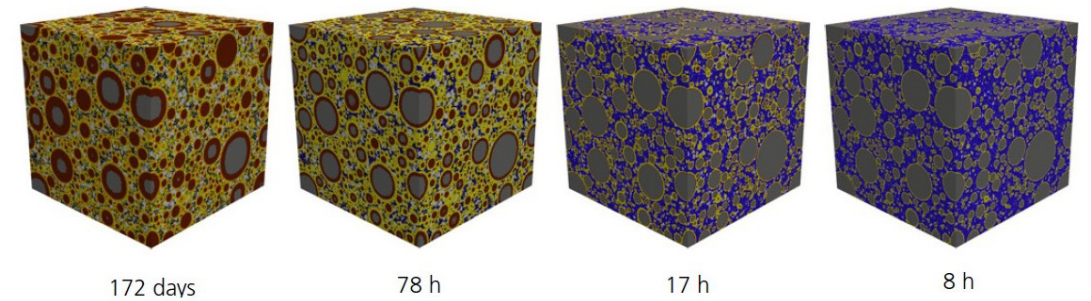
CSH with $\eta_{min} = 0.35$
CSH with $\eta_1 = 0.55$
CSH with $\eta_2 = 0.65$
CSH with $\eta_{max} = 0.74$
Unreacted cement
Capillary water
Empty capillary pores
CH

AARM 4.0 — High Strength Steels – Metalomechanics
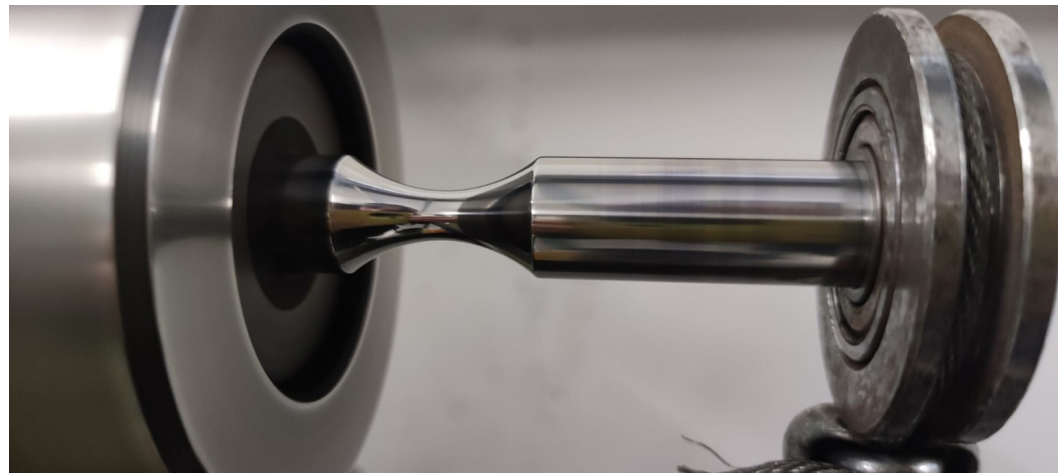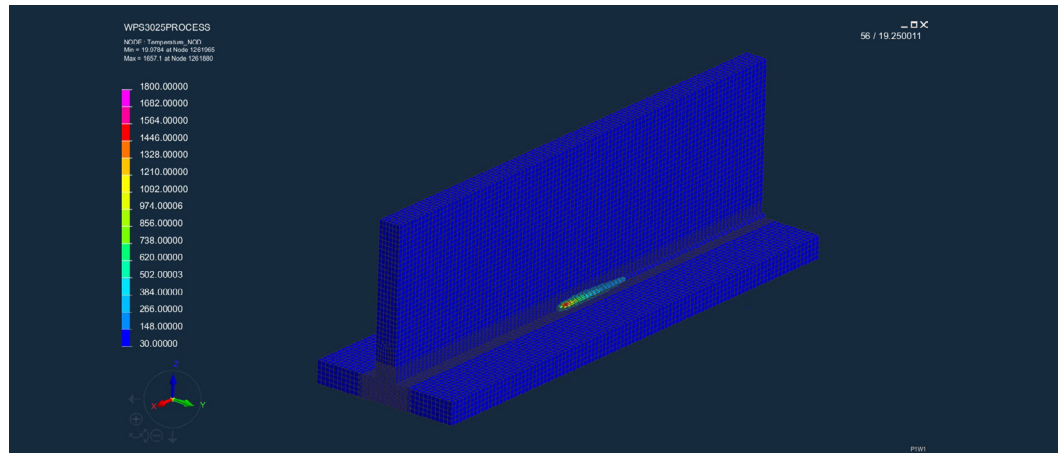
Principal Investigator
José Correia

Total funding
321 270€

Source of funding
Agência Nacional de Inovação S.A.

AARM 4.0 project aims to develop cutting and welding techniques in high-strenght steel, that are difficult to process but have advantages in terms of cost reduction and sustainability. This consortium intends to be pioneer in the construction of structures using this steel.

Continental FoF — Continental AA's Factory of the Future

Principal Investigator
Maria de Lurdes Lopes

Total funding
1 298 195€

Source of funding
Agência para o Investimento e Comércio Externo de Portugal, E.P.E

The Continental FoF Project aims to create new technical scientific knowledge that will enable the development of new technology-intensive products that, integrated, will create the Factory of the Future of CONTINENTAL AA, to meet the complex challenges facing the new generation of vehicles of the future.

In particular, it is intended to enable the total abandonment of the factory floor, creating an advanced and intelligent production system that is (1) flexible, modular and with capacity for mass customization, (2) digitally connected to the entire environment, (3) dynamic in the collection, reading treatment and interpretation of data, (4) autonomous and intelligent in decision making, (5) symbiotic in the relationship with the operator, (6) sustainable in the management of resources and (7) integrated with a dynamic and interactive logistics process, safeguarding real and effective control over product quality at all times.

In this project CONSTRUCT participates in the task of sustainable management of resources, namely through the Development of plans for the promotion of environmental sustainability, which will include a plan for the prevention and valorisation of waste in a circular economy context that aims to: a) reduce waste production; b) reduce the consumption of raw materials; c) and increase the % of waste sent for recycling.

CDW_LongTerm — Valorisation of Construction and Demolition Wastes in geosynthetic reinforced structures – Prediction of long-term behaviour

Principal Investigator	Total funding	Source of funding
Castorina Vieira	**206 907€**	**FCT · Fundação para a Ciência e Tecnologia**

The proper use of natural resources is one of the fundamental pillars for the sustainable development demanded to modern societies. Consequently, the European Commission (EC) has presented the European Union Action Plan for Circular Economy, to help European businesses and consumers to make the transition to a circular economy, where resources are used in a more sustainable way. Construction and Demolition is among the priority sectors identified in this Circular Economy Package. Construction and demolition wastes (CDW) have been identified by the EC as a priority stream because of the large amounts that are generated and their high potential for reuse and recycling. Despite this high potential, reuse and recycling rates vary widely across the EU. Within this framework, the promotion of research studies showing the suitability of the use of recycled aggregates coming from CDW for specific purposes needs to be encouraged and supported. A previous research project (funded by FCT and led by the PI) has shown that recycled CDW fulfil short-term requirements for their use as filling material of Geosynthetic Reinforced (GR) structures. This study has been used by some Portuguese companies as a stepping stone to implement the use of recycled CDW. However, being unconventional materials, their full implementation still finds significant resistance from owners and designers, especially due to lack of confidence regarding their long-term behaviour. It is thus of the utmost importance to demonstrate that GR structures constructed with CDW are durable and perfectly capable to maintain their excellent behaviour throughout their effective live. In recent years, several studies and applications of recycled CDW have been carried out and reported in the literature, but the knowledge related to the long-term behaviour of these alternative materials is still fairly limited. The innovative character of this project, which we believe represents a step forward on the current state of knowledge, regards the study of the long-term behaviour of recycled aggregates coming from CDW and of a geotechnical structure as a whole. Other singularity of this proposal is the use of mixed recycled aggregates obtained from non-selected CDW (ie concrete, mortars, ceramics), since most of the laboratory studies are carried out with selected CDW. The study of the long-term behaviour of GR structures constructed with recycled CDW requires the analysis of four main points: evolution with time of the environmental and mechanical behaviour of the recycled CDW; durability and creep behaviour of the geosynthetics inserted into recycled CDW; long-term behaviour of the interfaces between the geosynthetic and the recycled CDW; long-term overall behaviour of a full-scale GR structure. These four points are contemplated in the project. This project aims to promote the valorisation of CDW and therefore, will represent a significant contribution towards a resource efficient Europe.

Circular Buildings

Principal Investigator
Castorina Vieira

Total funding
8 915€

Source of funding
Mecanismo Financeiro do Espaço Económico Europeu

The construction sector is highlighted by the intensive use of primary resources, low material productivity and low circularity, wherefore it is essential that the agents involved have knowledge of the material composition of the building stock and material flows to enable a paradigm shift. The Circular Buildings project has as main goal the development of decision support tools to promote the increase in the reuse of materials and the reduction in waste production in the construction sector, namely through: - Guidelines for preparation of Material Passports for buildings - Good practices guidelines for promoting the circularity in Environmental Product Declarations (EPD) - Good practices guidelines to assess efficiency indicators of buildings - Calculation tools for the benefits related to the circularity of buildings. The tools to be developed allow the promotion of sustainable practices and circular economy principles in the construction industry, the effective planning of the rehabilitation and demolition of buildings and the reduction of related environmental impacts. The project is aligned with the objectives of the EU Construction & Demolition Waste Management Protocol and the Portuguese Government's Action Plan for the Circular Economy, through its contribution to improve waste identification, source separation, logistics, waste processing and treatment options, process quality, monitoring and control. The developed tools will be implemented in a demonstrator project.
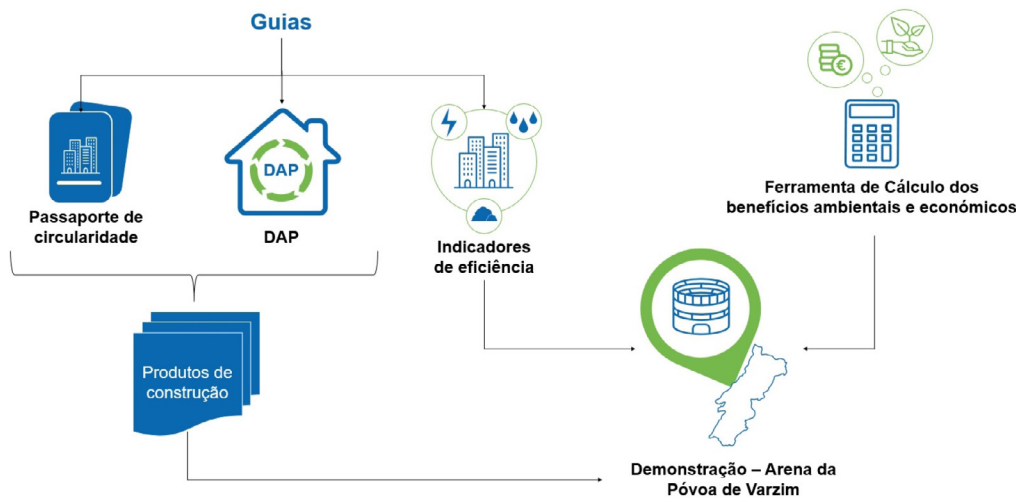
# SMARTER — Seismic Urban Risk Assessment in Iberia and Maghreb

Principal Investigator
José Miguel Castro

Total funding
86 088€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

This projects aims to improve the knowledge regarding the seismic hazard and risk assessment in urban areas in Portugal and Algeria, leveraging upon the expertise of the Faculty of Engineering of the University of Porto concerning earthquake structural modelling and risk assessment at national level, and the large experience of the Research Centre of Astronomy, Astrophysics and Geophysics (CRAAG), in particular its seismology division, in hazard assessment and collection of earthquake information. The North of Algeria is the most active seismogenic region in the Western Mediterranean basin, with an historic occurrence of frequent and very destructive earthquakes in this area, which had led in the past few decades to approximately 50.000 fatalities and a large economic, human and social impact {1}. Moreover, Portugal is a moderate seismicity country that has been partly destroyed in the past by large seismic events, such as the 1755 Lisbon earthquake {2}, which shook philosophical thoughts and redefined the importance of seismic causes and consequences in the European society {3}. Within this context, a unified hazard model will be defined for the North of Algeria, taking into consideration the seismic activity of the region and the extensive catalogue of seismic data collected by CRAAG. Several vulnerability models will be derived for the most important building typologies in both countries, and employed in city scenarios considering historical earthquakes and probabilistic seismic hazard. Moreover, post-earthquake damage information gathered from the most recent Algerian earthquakes, will be used to calibrate the derived vulnerability models. These results will be provided to the local authorities to support the development of risk mitigation measures, and incorporated in a web based platform for real-time communication and dissemination purposes of the consequences of earthquake events. Furthermore, steaming from the fact that Algeria is a major natural gas supplier of the Iberian Peninsula and the third-largest supplier to Europe, a special attention is drawn to the systemic seismic vulnerability assessment of the gas network (pipelines) in Algeria. The estimation of the economic impact and business interruption in the Portuguese territory, due to partial failures or collapses, will also be conducted. A strong collaboration and knowledge transfer between the complementary competences of FEUP and CRAAG is expected and will definitely grant the success of the project SMARTER, ensuring also that both Portuguese and Algerian societies will benefit from the outcomes of this initiative, increasing their resilience and preparedness to mitigate the impact of future earthquakes.
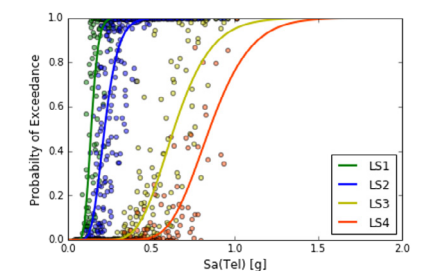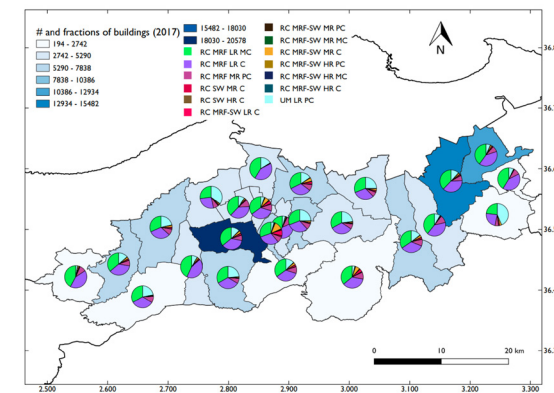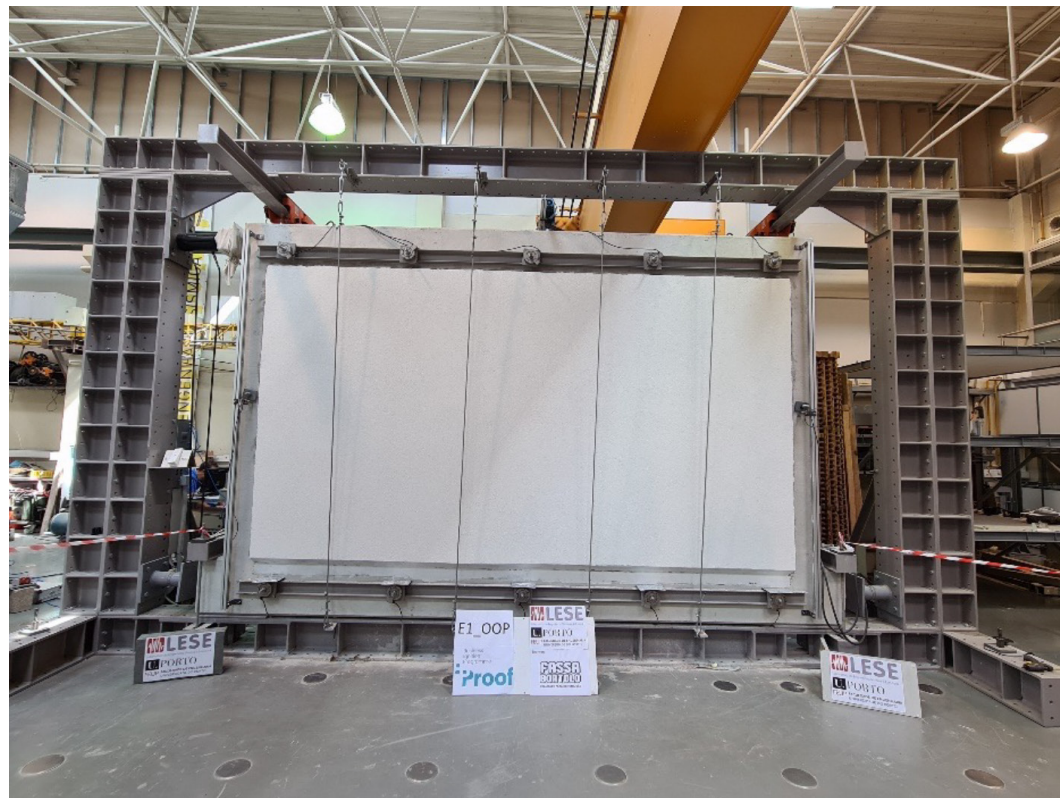
ASPASSI — Safety evaluation and retrofitting of infill masonry enclosure walls for seismic demands

Principal Investigator
Humberto Varum

Total funding
90 768€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The presence of infill masonry (IM) walls in reinforced concrete (RC) buildings is very common. However, and even today, in the design process of new buildings and in the assessment of existing ones, infills are usually considered as non-structural elements, and their influence in the structural response is disregarded. The influence of IM walls is recognized to be crucial in the global behaviour and performance of RC framed building structures when subjected to earthquake demands, as confirmed in the poor performance of many buildings damaged in recent earthquakes in Europe. Many authors recognize the need for the inclusion of IM panels in the numerical models adopted in the seismic assessment of existing buildings and in the design process of new buildings. The large in-plane shear demands that IM walls may attract, and the associated in-plane damage evolution are likely to increase their out-of-plane vulnerability. The eventual out-of-plane collapse of IM walls can result in serious human injuries and casualties and high economic losses, as experienced in recent earthquakes. The rigorous knowledge of all the aspects related to the behaviour of infilled framed structures, of their components (structural and non-structural elements) and of the phenomena interaction is fundamental to guide the designers in the assessment and strengthening of existing buildings. Nevertheless, the available knowledge in this regard is still very limited. Thus, the main goals of the research project proposed are: (1) characterization of the IM walls; behaviour when subjected to in-plane and out-of-plane loading; (2) development of innovative retrofit solutions for IM walls; (3) development of a simplified numerical tool for the analysis of the interaction for in-plane and out-of-plane responses of IM walls in RC buildings; (4) calibration of the numerical model, based on experimental results, accounting for different aspects, such as, in-plane/out-of-plane interaction, wall typologies, wall/frame contact conditions, retrofitting strategies applied, etc. This will be valuable for the assessment of existing RC buildings and for the safety assessment of the large building stock in Portugal, considering simultaneously the in-plane and out-of-plane response of the IM walls. The experimental results and conclusions, combined with development and calibration of the numerical models, is expected to contribute significantly to the upgrade of the limited information and knowledge currently available concerning the in-plane/out-of-plane cyclic behaviour of infilled RC framed structures, representative of the existing building structures (as-built or retrofitted). One of the major contributions of this research project proposed, in relation to past studies, is its focus in the study of IM walls behaviour subjected to combined in-plane/out-of-plane demands, better representing the complex behaviour and response of these elements when subjected to earthquakes. It is also pointed out that the topic of IM walls' design and assessment will be specifically addressed in the revision of Eurocode 8 (which will occur in parallel to this research project). Furthermore, retrofitting solutions will be developed and tested, using innovative materials such as steel elements, textile fibres, Glass/Carbon Fibre Reinforced Polymers (GFRP/CFRP) and High Performance Fibre Reinforced Mortars (HPFRC). The retrofitting solutions to be studied will be designed and detailed considering economic, feasibility for real applications and environmental sustainability concerns. The design objectives of the retrofitting solutions for the IM walls will consider: (i) the stiffness compatibility between the retrofitting system and the existing frame and IM wall system; (ii) a clear definition of the retrofitting objective (in terms of improvement of the in-plane and/or out-of-plane performance of the infill walls); (iii) damage limitation for in-plane demands; (iv) detachment and out-of-plane collapse prevention of the walls for ultimate demand conditions. Based on the calibrated simplified model for the IM walls, for the as-built; and retrofitted walls, RC buildings vulnerability can be assessed for different earthquake demand levels, considering the influence of IM walls and including retrofitting solutions. Parametric analyses for the variables influencing the response (frame, IM materials and details, retrofitting system and details) will be developed. This simplified model will allow the evaluation of the benefits of each retrofitting strategy in the seismic performance upgrading of buildings.

ASSIMILATE — Seismic Risk Assessment through Artificial Intelligence and Vibrations

Principal Investigator
Humberto Varum

Total funding
51 694€

Source of funding
FCT - Fundação para a Ciência e Tecnologia
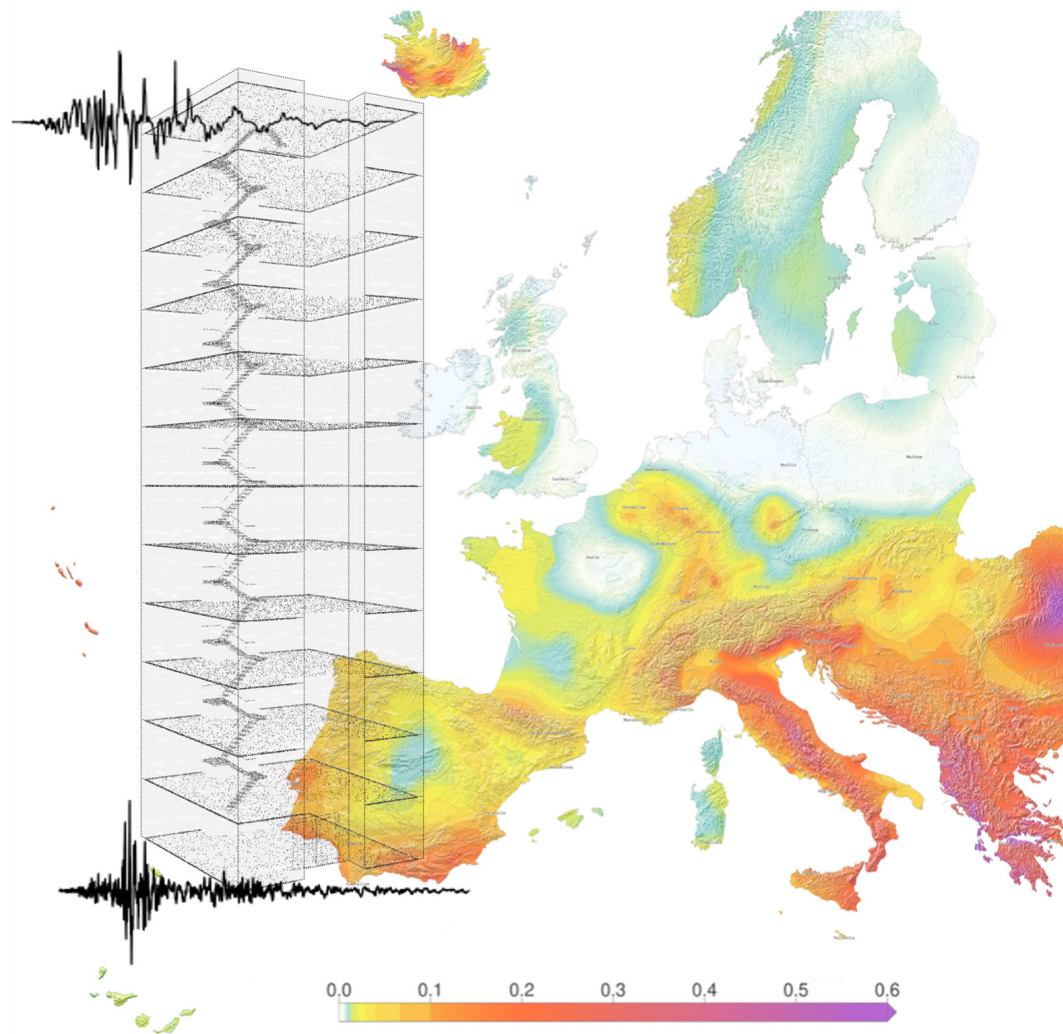
Seismic vulnerability and risk assessment are essential steps to better understand, and eventually mitigate, the impact from earthquakes. Prior to the occurrence of destructive earthquakes, risk assessment can support decision makers in the development of retrofitting interventions, or in seeking insurance coverage. An inaccurate assessment of the risk might lead to an overestimation of the level of safety, discouraging houseowners to take measures to reduce their risk. After the occurrence of an earthquake, it is critical to rapidly assess the potential impact and distribute the available resources effectively. Emergency rescue reports from past earthquakes indicate that 95% of the successful rescues of people trapped under debris occur within the first 48 hours, which emphasizes the need to rapidly identify areas in need of support. The assessment of earthquake risk and the rapid estimation of damage are challenging tasks affected by large uncertainties. It is thus important to explore new technologies and tools to improve the process of assessing the seismic safety of buildings before and after the occurrence of destructive events. Recently developed low-cost sensors to measure vibrations and open-source artificial intelligence tools have the potential to revolutionize the manner in which earthquake damage and risk is assessed. These devices have the capability to transfer data in real-time, and measure ambient vibrations at the top of buildings or ground motion at the foundation. These vibrations can be used to calibrate vulnerability models or to estimate the expected damage after the occurrence of destructive events. Despite the usefulness of such technology, there are still challenges in its employment, which currently prevents its effective application. While the measurement of the dynamic properties of a single building to calibrate a numerical model is commonly performed, their integration on vulnerability modelling for building portfolios has not been explored. Consequently, monitoring data is rarely used for the calibration of vulnerability functions for large building portfolios, thus hampering their exploitation in risk modelling, which could improve considerably the quality of loss models. On the post-event side, data regarding the structural response of buildings is not used on an operational basis, and seismic networks are sparse and limited to a few stations per urban centre. For example, mainland Portugal has less than 50 recording stations in its territory, which prevents the accurate estimation of ground shaking in the populated areas. The reasons for the inability to integrate monitoring data in portfolio risk analyses or to accurately estimate structural damage are due to the high costs involved in the instalment and maintenance of sensors, as well as lack of knowledge regarding the integration of large complex datasets (big data) in vulnerability and loss assessment. The former issue is now being overcome with the availability of low-cost sensors, while the latter challenge is being revolutionized by artificial intelligence (and in particular machine learning) technology that can process large amounts of data to predict complex outcomes. Some of the open-source tools allow researchers to integrate machine learning into their computational frameworks. In vulnerability modelling and damage assessment, machine learning enables the incorporation of a wide range of data regarding the dynamic properties of structures to better calibrate numerical models, as well as the exploration of a multitude of structural response and ground motion parameters to better estimate shaking and damage in near-real time. This project will combine low-cost devices with machine learning technology to develop a platform for vulnerability and damage assessment. To this end, a large number of buildings will be monitored, and the recorded data will be used to develop a framework to calibrate numerical models relying on machine learning technology. Moreover, data recorded from past events will be explored to expand the framework to the estimation of damage and losses using monitoring data captured in near-real time. The consortium involves partners with decades of experience in seismic monitoring, vulnerability modelling and processing of large datasets using machine learning. Such an approach will mitigate several limitations in the current practice regarding vulnerability assessment and rapid loss estimation. This project has several stakeholders such as the Portuguese Civil Protection Authority, the Portuguese Institute of the Sea and Atmosphere (which monitors seismic activity), the National Laboratory of Civil Engineering, the Global Earthquake Model Foundation and SafeHub. It also contributes to the goals of the international agendas of the Sendai Framework and the United Nations 17 Sustainable Development Goals, which ask specifically to better understand risk and reduce the impact of natural hazards.

SafEarth — Seismic protection of earthen construction heritage

The construction with raw earth still has an important presence around the World, where it constitutes one of the most ancient methods for building. This importance is confirmed by the fact that about one third of the World Population lives in an earth construction. Furthermore, this type of construction shows a large world distribution, which includes even regions with important seismic hazard. The construction of housing is its main use. However, several military, religious and monumental buildings built with earth exist and present an important cultural, historical and architectonic value. Such importance is proven by the fact that about 10% of sites and monuments classified as World Heritage by UNESCO are built with earth. The great availability and low-cost of earth as a building material explains the great popularity of this type of construction in developing countries. On the other hand, nowadays the use of earth construction in developed countries is marginal, being supported mainly by the high sustainability and architectonic interest of this type of construction. The Portuguese case is an example of this situation, but where a large earthen built heritage still exists. Adobe construction was mainly used in the region "Litoral-Centro", namely in buildings of the "Art Nouveau" style, whose cultural, historical and architectonic value is relevant. Rammed earth construction was mainly used in the regions of "Alentejo" and "Algarve" both in the construction of dwellings and of millenary fortresses with great historical importance. Earth constructions are known for presenting poor seismic performance, evidenced in important earthquakes, such as El Salvador, in 2001, Bam, in 2003 and Peru, in 2007. In Portugal, there is a general lack of knowledge on the seismic behaviour of the local earthen heritage. This unawareness relative to the safety becomes critical, since this heritage is built on regions with important seismic hazard and is often found in poor conservation condition. Nowadays, the rehabilitation of the earthen heritage assumes great interest, namely in what concerns its housing and touristic valorisation. Moreover, the experience of the aforementioned earthquakes shows that a sustainable rehabilitation must address seismic strengthening.

The seismic behaviour of adobe construction is a topic which has been studied, namely in Peru, where shaking table tests have been performed. Nevertheless, the development of specific methodologies for seismic safety assessment, including adequate performance parameters, is still required. The seismic strengthening of adobe constructions is still a topic deserving being more studied, but like for the safety assessment, the development of reliable design is lacking. The case of rammed earth is even more critical, since the seismic study of these constructions is still very limited.

Taking into account the described scenario, this project intends to contribute critically to the development of the national and international knowledge related with the seismic behaviour of adobe and rammed earth construction. Furthermore, the development of an integrated approach for the seismic strengthening of these constructions with geo-mesh reinforced coatings is also intended due to the good effectiveness and low cost presented by this solution. In this way, it will be possible to harmonize the rehabilitation of the earthen built heritage, or even requirements of strengthening, with adequate seismic safety needs.

The proposed objectives will be fulfilled by means of a methodology based on the following integrated steps:

· Identification of the parameters influencing the seismic performance and assessment of the respective level of importance with basis on data-mining techniques;
· Characterization of the seismic behaviour of adobe and rammed earth constructions with basis on quasi-static and dynamic (on shaking table) experimental tests;
· Assessment of the effectiveness of the seismic strengthening with geo-mesh reinforced coatings with basis on quasi-static and dynamic experimental tests;
· Calibration of numerical models for the simulation of the dynamic behaviour of adobe masonry and rammed earth elements, complemented by parametric analyses for identification and definition of critical seismic performance parameters;
· Development of guidelines for seismic safety assessment of adobe and rammed earth structures and for the design of the strengthening with geo-mesh reinforced coatings.

The presented methodology will be implemented by a team of experts highly involved and active in the area of earth construction, structural dynamics and numerical modelling. The results of the project will have great utility for the scientific and technical community dealing earth constructions and will support the rational rehabilitation of the earthen heritage.

SAFE 3D PRINTED-CS — Seismic and energy Assessment of the perFormancE of 3D PRINTED Concrete Structures: tests on thermal and seismic performances
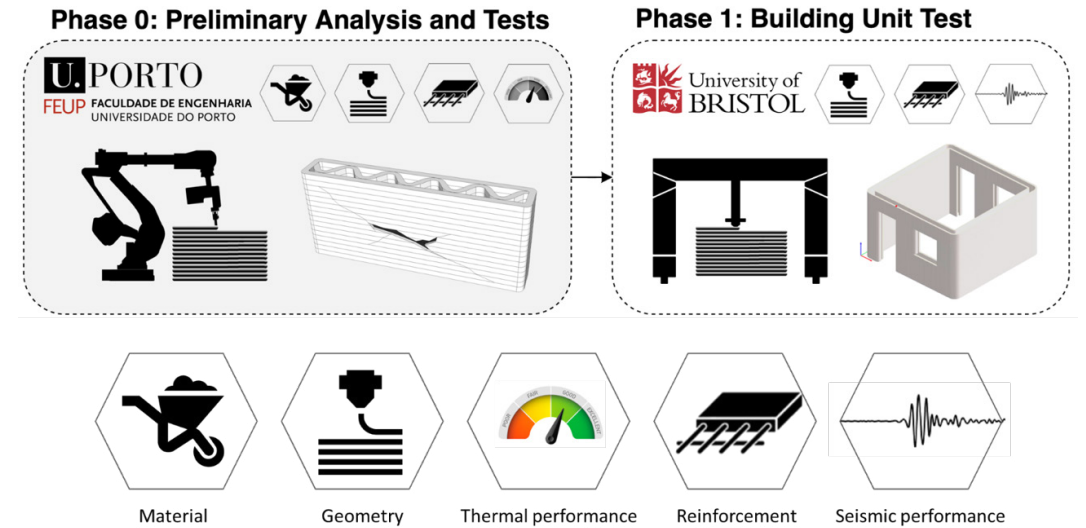
Principal Investigator
Humberto Varum

Total funding
50 000€

Source of funding
European Commission

The building construction sector typically takes advantage of the benefits of technological progress late in comparison with other sectors. On the other hand, in the last decade, unprecedented development and diffusion of novel technologies in the building sector have been observed through the advent of 3D printing and additive manufacturing technologies. Several companies have developed 3D construction printing systems and several buildings are being built worldwide. Even if 3D printed building and component applications are numerous and increasingly complex, the performance assessment from a structural and seismic viewpoint of this new construction technique is yet to be fully assessed and verified. Moreover, the mechanical and thermal characterization of the 3D printed material (concrete) and of the printed walls is missing in the literature published to date. In this context, this project proposes a series of sequential tests that start from the characterization of 3D printed materials and walls in different configurations up to the final test of a full-scale 3D printed building unit. The scope of the proposal is threefold: a) characterize the mechanical characteristics (orthotropic) of the 3D printed concrete: b) calibrate a numerical model to simulate tests up to failure of single walls and full buildings and c) advance our knowledge of 3D printed construction printing performances and start developing design guidelines for companies and professionals. More specifically, the proposed research will investigate five features: i) characterization of the printed material both with and without fibre reinforcement, ii) characterization of 3D printed walls considering different infill geometries, iii) assessment of different reinforcement techniques, iv) assessment of the walls'thermal performances and v) verification of the seismic performance of a full-scale building unit (building unit of about 4x4 m) designed following the indications of the preliminary tests and the expertise of the proposed team.

Phase 0: Preliminary Analysis and Tests

Phase 1: Building Unit Test

Material · Geometry · Thermal performance · Reinforcement · Seismic performance

AR-SeismicRC — Assessment and retrofitting of non-seismically conforming existing reinforced concrete building structures and validation of the corresponding Eurocode 8-3 recommendations

Principal Investigator
Humberto Varum

Funding FEUP
121 371€

Total funding
249 599€

Start: March
2023 (3 years)

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The current knowledge of the seismic behaviour of new reinforced concrete (RC) structures still needs to cover some validation gaps. An example of this is the new design methodology of beam-column joints, that is available in the draft version of EN 1998-1-2:2021 (EC8 – New structures), which needs experimental validation for new ductility classes (DC1, DC2 and DC3).

In the case of existing structures, the need for validation of seismic safety methodologies and seismic actions, present in the draft standard EN 1998-3:2021 (EC8 – Existing structures), are even more relevant. Example of this, is the lack of experimental results on RC columns with plain or deformed bars without proper seismic design and detailing, subjected to bi-directional horizontal loading.

The beam-column joints cyclic behaviour, representative of existing RC structures, is complex and is a determining factor on the global behaviour, which means that the full-scale testing will help to characterize their cyclic behaviour more accurately. Moreover, the experimental results are essential to develop and validate analytical and "semi-empirical" design equations and to develop and calibrate numerical models that nowadays show some limitations in simulating existing RC buildings. The poor seismic performance of structures is the result of inadequate design practices and procedures, such as the use of plain reinforcing bars (until 1970s) and a simplified and limited seismic design (until 1980s).

This project aims to develop and validate experimentally innovative seismic strengthening strategies (I3S) for existing RC structures. Thus, the main objectives of this project are:

1) Characterization of the seismic behaviour of non-conforming existing RC structures;

2) Validation of the methodology and equations available in the draft EN 1998-3:2021 concerning the seismic assessment of existing RC structures;

3) Study, development, implementation and validation of I3S for existing structures;

4) Development and calibration of numerical models capable of simulating the behaviour of the tested specimens.
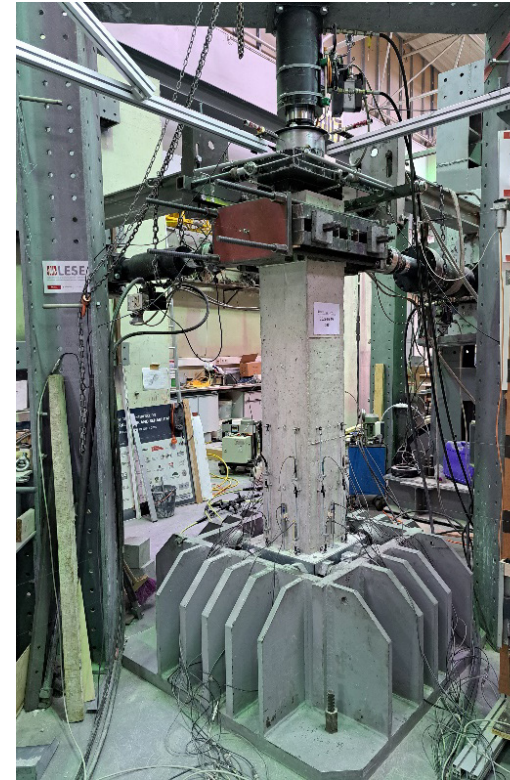
SERENE — Optimal Seismic and Energy Retrofit of Buildings considering EcoNomic and Environmental Impacts

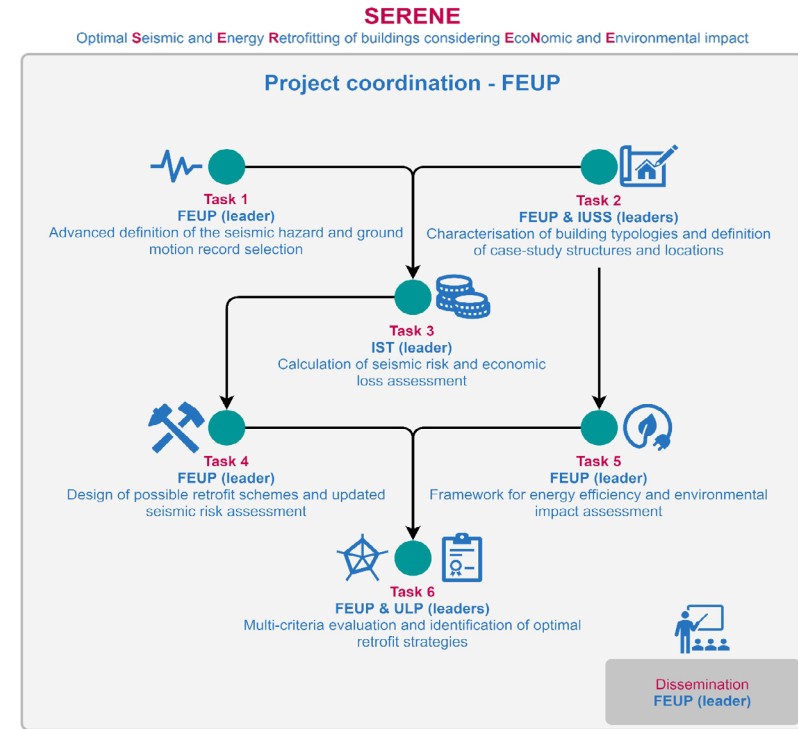Principal Investigator
Ricardo Monteiro

Funding FEUP
121 371€

Total funding
50 000€
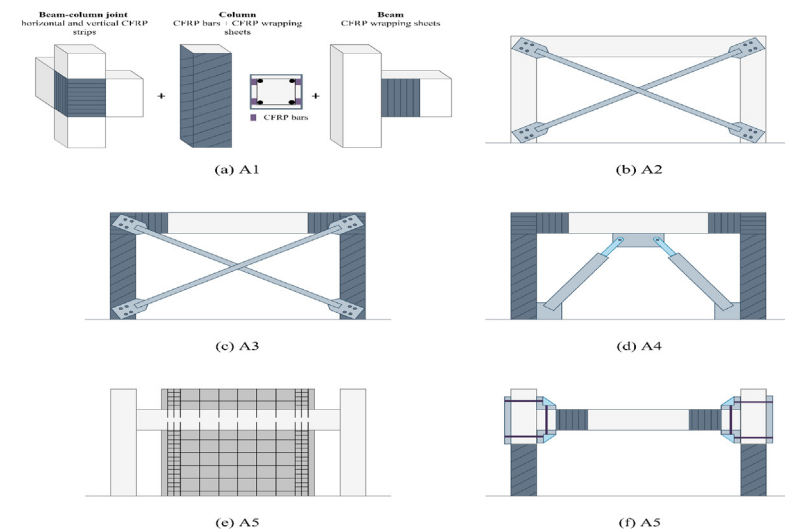
Start: March
2023 (3 years)

Source of funding
FCT - Fundação para a Ciência e Tecnologia, I.P.

A significant portion of the Portuguese building stock consists of structures built before the introduction of the first seismic design codes in the country, in the early 1980s. As a result, many of these structures have not been designed to withstand the demands from potential earthquakes and pose a significant risk in terms of economic and human losses. In addition, it is well-known how many of the Portuguese buildings are energy deficient, requiring important renovation interventions to increase their energy performance, hence level of comfort, and reduce the associated environmental impact. For these reasons, the main goal of SERENE is to propose and demonstrate a framework to integrate, in an optimal manner, the seismic and energy retrofitting of existing buildings, with a view to minimise the resulting economic and environmental impacts. SERENE aims to provide a scientifically solid framework to identify the optimal combinations of building retrofitting interventions that will increase the energy and seismic performance of residential buildings in the Portuguese territory (as seen in the attached flowchart). It will achieve so using a multi-criteria decision-making optimization procedure settled on life-cycle based performance metrics. Such metrics will rely on advanced and ad-hoc hazard, exposure and vulnerability models for different building structural typologies. Furthermore, combined retrofitting strategies will guarantee the minimisation of economic and environmental impacts thus targeting increased sustainability and best use of resources. The research scope of SERENE is therefore also fully in line with the country's Sustainable Development plan for the 2030 Agenda. The project will be carried out by renowned institutions in the country, with consolidated experience in risk assessment and loss estimation of existing buildings and features the participation and support of two European leading institutions, IUSS Pavia, through its ROSE programme and the EUCENTRE, with long-term leading experience in the field of seismic risk and recent experience in the integration of seismic and energy performance of existing structures. SERENE will provide advanced seismic risk models, necessary to define structural retrofitting needs that can be integrated with energy efficiency renovation strategies, promoting sustainability and environmental impact mitigation. The project will focus on residential buildings and attention will also be paid to dissemination of outputs for wider societal exploitation. In addition to the engineering community, the beneficiaries will also be public and private decision-makers) responsible for maintaining and safeguarding the Portuguese residential building stock.

(a) A1

(b) A2

(c) A3

(d) A4

(e) A5

(f) A5

Proj HiPerSlab — Enhancement of the Structural Behaviour of Flat Slabs under Cyclic and Seismic Actions through the Rational Use of High Performance Fibre Reinforced Concrete
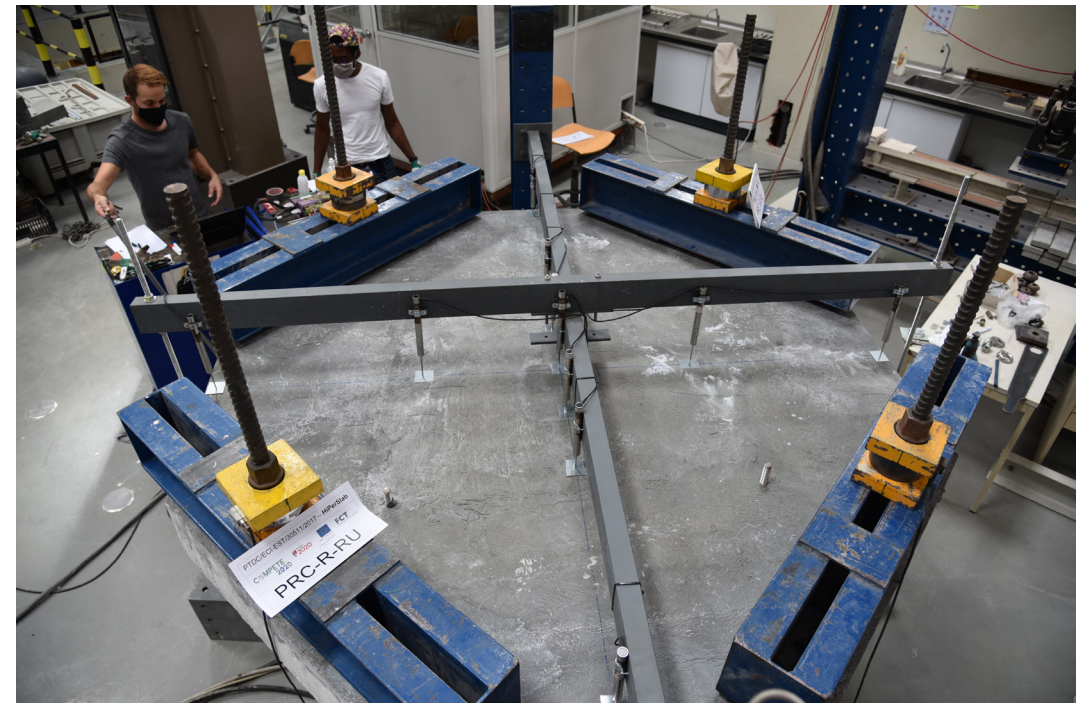
Principal Investigator
Sandra Nunes

Total funding
39 325€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Flat slab buildings for commercial, office and residential use are a common solution in Portugal, as well as in many other countries. Nevertheless, its behaviour under gravity and seismic actions is still not very well understood by the scientific community. The EuroCode EN1998.1, prescribes in 5.1.1(2)P: "Concrete buildings with flat slab frames used as primary seismic elements in accordance with 4.2.2 are not fully covered" by the EC8 section on concrete structures. This statement results from the lack of knowledge about the stiffness of the slab-column connection and the brittleness of the punching failure. It is also the consequence of insufficient knowledge about the behaviour of flat slabs under seismic actions and the need for further research on the punching behaviour and resistance under cyclic and dynamic horizontal loading. High and Ultra High Performance Fibre Reinforced Concrete (HPFRC and UHPFRC) are relatively recent materials that present higher durability and mechanical resistance when compared to Normal strength concrete (NSC). These high performance materials give the opportunity to design slender, lighter, elegant and efficient structures. Another innovative aspect of the use of these materials, associated with slenderer structures, is the use of less amounts of raw materials in its manufacture, with less environment impact. However, insufficient established design rules have been obstacles to a larger use of HPFRC and UHPFRC in structural design. Being more costly materials, when compared with the NSC, it is also imperative to study its rational structural use. One of our objectives is the use of HPFRC and UHPFRC in localized areas at the slab-column connection, being the remnant slab cast with NSC. This way we can minimize the economic impact of using the HPFRC/UHPFRC and enhance its competitiveness. In a preliminary phase some punching tests of flat slab-column connections under vertical monotonic loading will be performed, to access the potential benefits of different geometry layouts, with the localized and rational use of HPFRC/UHPFRC. Afterwards, some more tests will be performed under reversed cyclic horizontal actions until failure, to better understand the behaviour of this kind of structures under earthquake induced deformations. The experimental tests will be accompanied with non-linear numerical modelling of the column-slab connections, and subsequently a parametric analysis, due to lower costs and preparation time, and the possibility to analyse a higher number of cases with FEA than with experimental tests. The research proposed in this project aims to increase the knowledge on the behaviour of HPFRC/UHPFRC structures. It also has the purpose to suggest design recommendations for safer structures, particularly under seismic actions. The research is strong-minded in the safety of people and in the economy of the construction industry. These objectives will be reached with experimental and numerical research.

SeismicPRECAST — Seismic performance ASSessment of existing Precast Industrial buildings and development of Innovative Retrofitting sustainable solutions
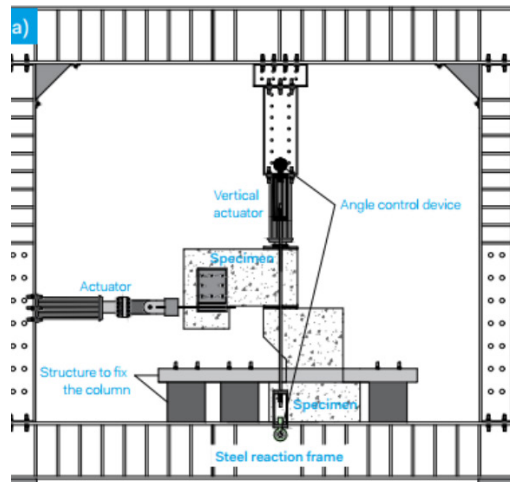
Principal Investigator
Humberto Varum

Total funding
39 325€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The main aim is to study the existent precast industrial building stock existent in Portugal. Based on the characterization, it will be evaluated the seismic vulnerabilities to identify the major issues, and guide the development of the retrofitting solutions. The development of the retrofitting solutions will be based on structural criteria?s, feasibility of the solution, to be implemented in existent structures, and considering a life cycle assessment (LCA) of the global solution to assure the minimum environ-mental impact along the infrastructure life cycle. In the end the results will be disseminated by the research community with journal papers and conferences participation and for practical engineers with the development of a guidelines for the assessment and retrofitting of existent precast industrial building. The project will be leaded by the IP-Leiria with the collaboration of the UA, supporting the LCA and the FEUP supporting the development of the retrofitting solutions.

SERA — Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe
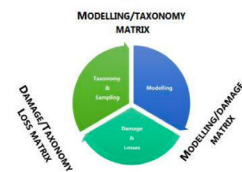
Principal Investigator
Humberto Varum

Total funding
75 000€

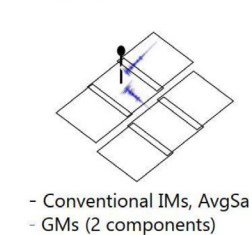Source of funding
European Commission

SERA is the "Seismology and Earthquake Engineering Research Infrastructure Alliance for Europe", responding to the priorities identified in the call INFRAIA-01-2016-2017 Research Infrastructure for Earthquake Hazard. The overall objective of SERA is to give a significant contribution to improve the access to data, services and research infrastructures, and deliver solutions based on innovative R&D in seismology and earthquake engineering, aiming at reducing the exposure of our society to the risk posed by natural and anthropogenic earthquakes. To this end, SERA will: Involve the communities involved in previous successful projects including NERA and SERIES; Offer transnational access to the largest collection of high-class experimental facilities in earthquake engineering; Offer virtual access to the main data and products in seismology and anthropogenic seismicity; Promote multi-disciplinary science across the domains of seismology, anthropogenic seismicity, near-fault observatories and deep underground laboratories, to achieve an improved understanding of earthquake occurrence; Revise the European Seismic Hazard reference model for consideration in the ongoing revision of the Eurocode 8; Develop the first comprehensive framework for seismic risk modeling at European scale; Develop the new standards for future experimental observations in earthquake engineering and for the design of future instruments and networks for observational seismology; Develop reliable methodologies for real-time assessment of shaking and damage; Expand access to seismological observations; Network infrastructures and communities in the fields of deep seismic sounding, experimental earthquake engineering and site characterization; Provide an important contribution.
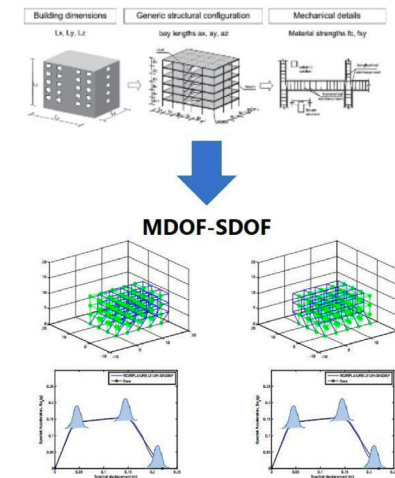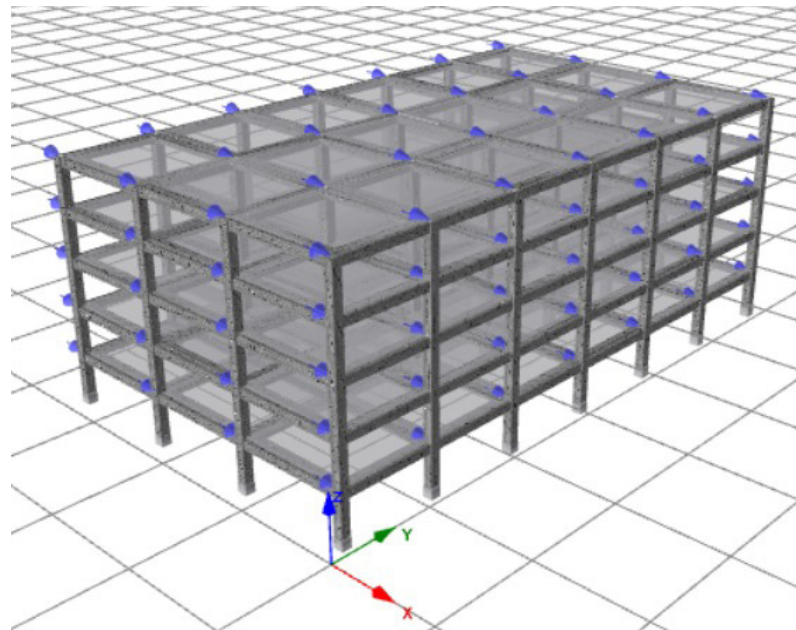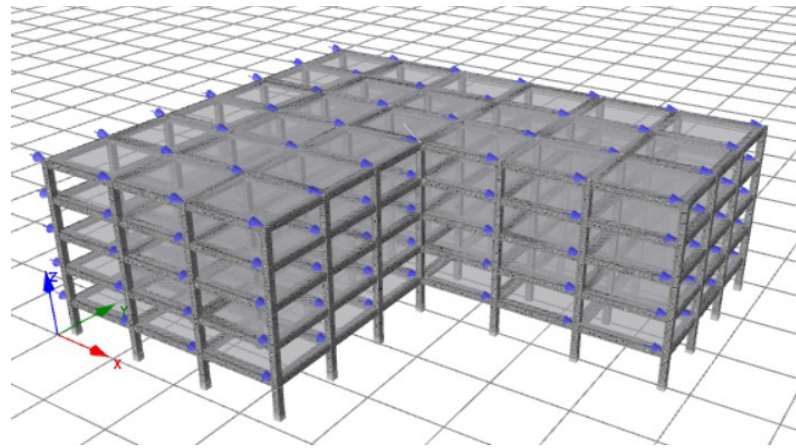
ERES2 - Evaluation and Retrofitting of Existing Buildings for Safe and Sustainable Built Environment

INDIA–PORTUGAL PROGRAMME OF COOPERATION IN SCIENCE AND TECHNOLOGY – FCT

Principal Investigator
Humberto Varum

Total funding
99 841€

Source of funding
FCT · Fundação para a Ciência e Tecnologia

Safety and sustainability of ageing and degrading infra-structure is a crucial concern, not only in the developed world but also in developing countries. Buildings, the most important component of urban habitat are subjected to degradation and failure due to many natural and man-made factors, including disasters. India and Portugal have distinct similarities in terms of the prevalently used construction materials and building typologies. Further, earthquake is a common hazard, threatening the built environment, in both the countries, and has caused destruction in past. A significant proportion of the housing stocks in India and Portugal are the buildings which were constructed prior to the 'modern-code' era and these buildings offer several deficiencies in their structural design and detailing, mainly either due to lack of enforcement or availability of adequate seismic design provisions at the time of their construction. Further, in due course of time, these buildings have deteriorated due to the natural process of ageing or inappropriate human interventions and usage. Evaluation and development of appropriate retrofitting measures to enhance 'safe-life' of this huge stock of existing buildings is one of the current and challenging tasks for the researchers as well as the policy-makers. Recent decades have witnessed tremendous development in the field of earthquake and structural engineering, including estimation and communication of risk. In this backdrop, the research work is aimed at developing detailed guidelines, methods, and tools for safe-life assessment of the existing buildings, and appropriate retrofit techniques to enhance their safety and sustainability.
The objectives of the work are:
· Document the prevalent building typologies in the Indian and Portuguese building stock based on the information available in the published literature, and limited field survey in test bed cities;
· Develop numerical models representative of the most commonly used building typologies, in both the countries, and assess their seismic vulnerability, including the effect of ageing and deterioration;
· Identify appropriate retrofit techniques to enhance the safety and sustainability of the chosen building typologies;
· Assess the efficacy of the retrofit techniques by studying the reduction in risk of failure, under the expected seismic scenario, and enhancement in the 'safe-life';
· Demonstrate the developed methodology by studying the seismic risk of a representative community/test-bed in both the countries, before and after the retrofitting.

The project will provide a methodology for estimation and reduction in seismic risk through retrofitting of existing housing stock. Currently, a number of seismic hazard microzonation exercises are underway in different cities in India and Portugal. The natural extension of these studies is estimation and mitigation of the associated risk. Unavailability of seismic vulnerability of the existing housing and infrastructure is the main bottleneck in this exercise. The proposed study will provide a crucial input to this exercise, in the form of the methodology to assess the vulnerability of existing and ageing building stock. In addition, the study will also provide appropriate retrofit techniques and tools to assess their efficacy in achieving the targeted goals. Currently, India is lacking a comprehensive standard on seismic evaluation and retrofit of existing buildings. This project will also provide the crucial input for development of the standard.

# ITERATE — Improved Tools for Disaster Risk Mitigation in Algeria

Principal Investigator
José Miguel Castro

Total funding
169 842€

Source of funding
European Commission

Following major disasters, it is evermore recognised that while their occurrence is often inevitable, reducing the associated risk through prevention measures should be a primary concern. Regions with a significant percentage of non-seismically designed buildings and where there is room for improvement in urban planning are particularly vulnerable to natural hazards. As such, ITERATE aims at disaster risk reduction in Algeria through prevention measures. Indeed, Algeria is exposed to a number of natural hazards, such as earthquakes, floods, draughts, and forest fires; all posing a great threat to both human lives and local economies. In particular, earthquakes can have a devastating impact, as has been shown by past events in the northern part of the country like the El Asnam 1980 Mw 7.1 and Boumerdés 2003 Mw 6.8 earthquakes. In 2004 the country adopted the Law on Prevention of Major Risks and Disaster Management and the National Scheme for Land Use Planning, demonstrating its political will to promote disaster risk reduction (DRR). New seismic design regulations were also adopted, while in 2012 the National Delegate for Major Risks was established. The accomplishments in legislative and higher administration level have not, however, been followed by an equally successful integration of the new regulations at the local level. Limited resources and capacities, lack of cross-sectoral coordination and, mainly, awareness among several stakeholders have impeded the full implementation of the conceived policies. ITERATE intends thus to diminish these obstacles through an improved framework for seismic risk assessment that can be replicated to other natural hazards, making use of a geographical and scientific privileged combination of expertise in Algeria, Portugal and Italy. The knowledge of CRAAG (DZ) in seismic hazard will be fine tuned with real exposure and physical & social vulnerability models, building upon the experience of IUSS (IT). A user-friendly web-based platform (WBP) will be set up by FEUP (PT), putting together, in the open, all the necessary information on the different risk components, as an integrated tool for decision making. Different public and private stakeholders in Algeria will be involved in risk awareness raising and training initiatives, in a true collaborative effort, optimising existing and newly developed tools for increased resilience.
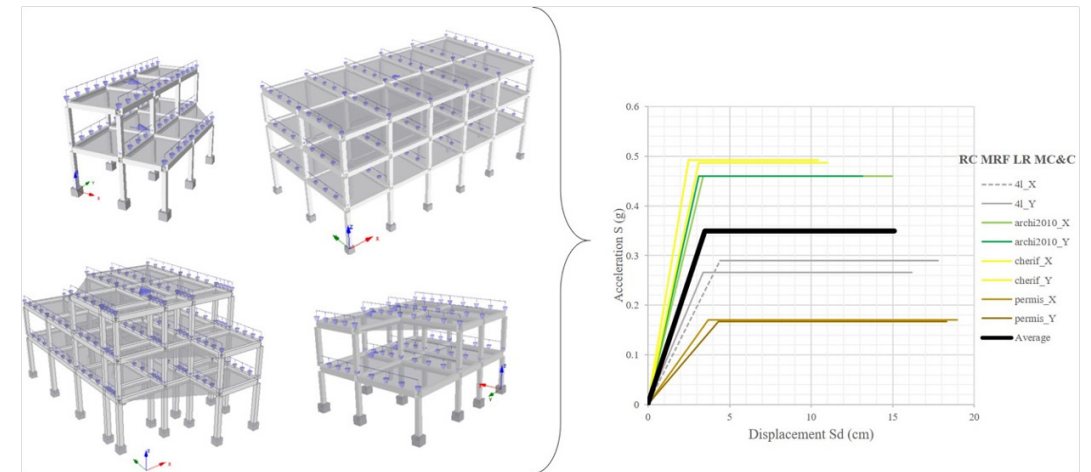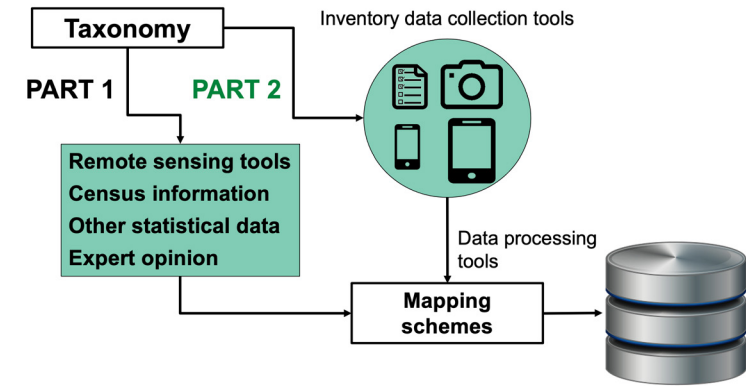
MitRisk — Framework for seismic risk reduction resorting to cost-effective retrofitting solutions

The main objective of this research project is to develop a platform for cost-benefit analysis that will enable the preparation of seismic retrofitting plans focused on the most vulnerable building typologies, namely those prior to 1983, which characterize the Portuguese building stock. To achieve this goal, a set of models that integrate the process should be used. risk and loss assessment, namely seismic hazard, exposure, vulnerability and the relationship between damage and loss. It is expected that the cost-benefit ratio maps will provide valuable information for political and private decision makers in prioritizing the regions to intervene, as well as in the proposal of optimized reinforcement solutions among several technically reliable alternatives. These solutions will also be of interest to the civil engineering community
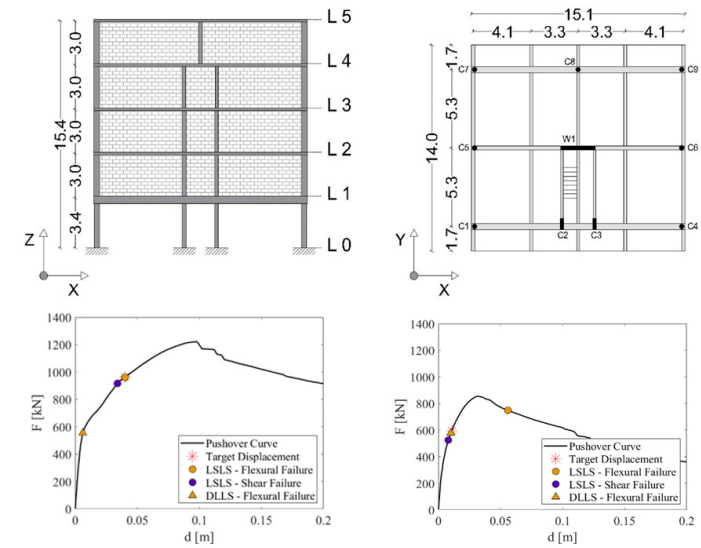
LOSS ANALYSIS – PROBABILITY OF COLLAPSE
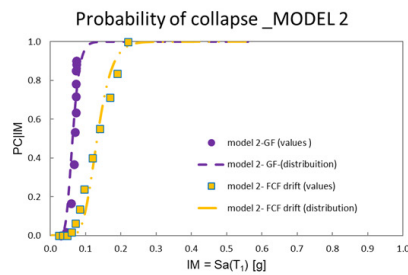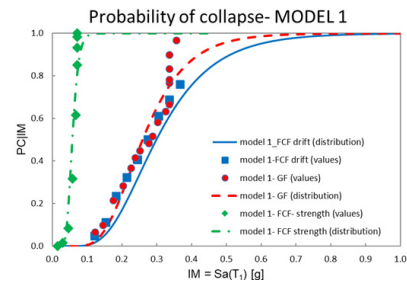
LOSS ANALYSIS – TOTAL LOSSES
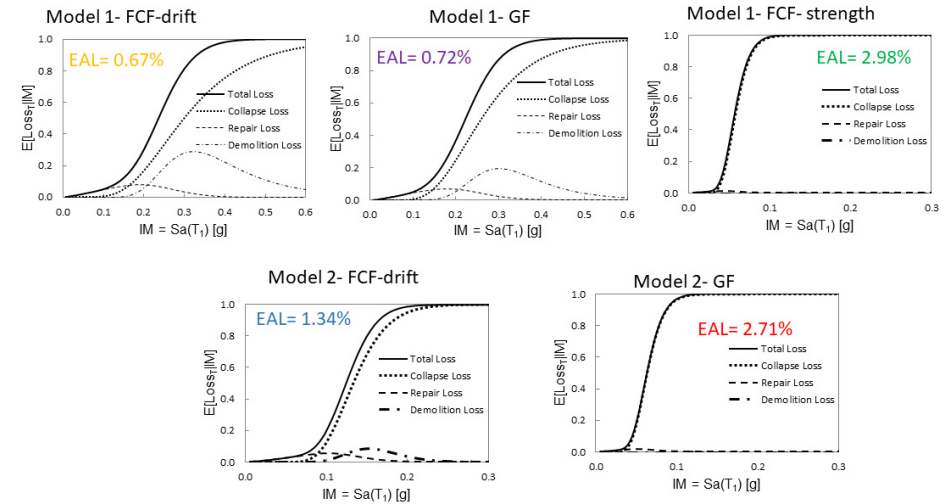
Expected Annual Losses (EAL)

$$EAL = \int_0^\infty E[Loss_T | IM] \cdot d\lambda(IM)$$
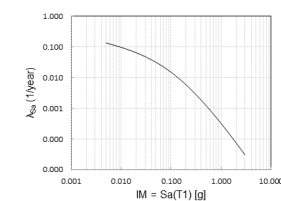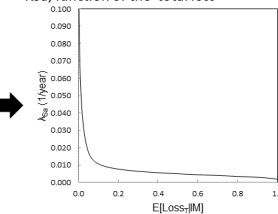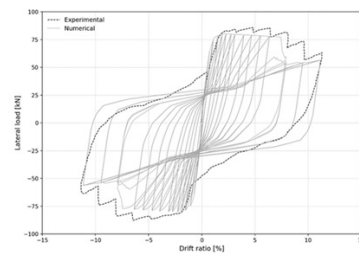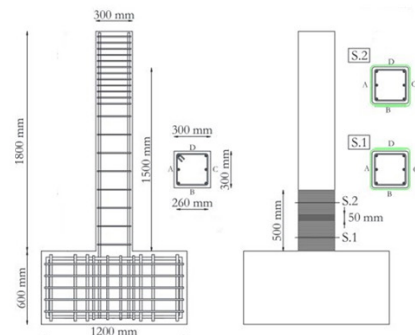
RIACT — Risk Indicators for the Analysis of Cultural heritage under Threat

Principal Investigator
Xavier Romão

Total funding
238 321€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The RIACT project is developing a unified approach applicable at the national and international levels for the definition and quantification of simple risk indicators for immovable cultural heritage (CH) assets exposed to human-induced and natural hazards. Although risk analyses of single CH assets can be performed at relatively low costs, the same analysis (and its update over time) extended to a large number of assets requires resources usually unavailable. Therefore, analysing risks for a large number of CH assets with limited resources in an efficient and timely manner is only possible if simple indicators are used. As such, RIACT is defining methods for the efficient risk and vulnerability assessment of CH assets based on an existing methodology developed by the RIACT team for seismic risk analysis that will be extended to other hazards.

$$I_{LV} = \frac{TRLV \times GVA + RC}{GDP}$$
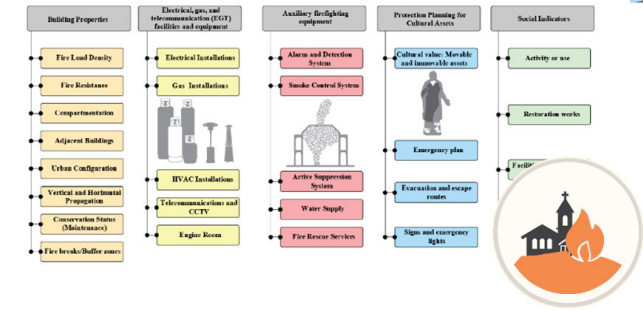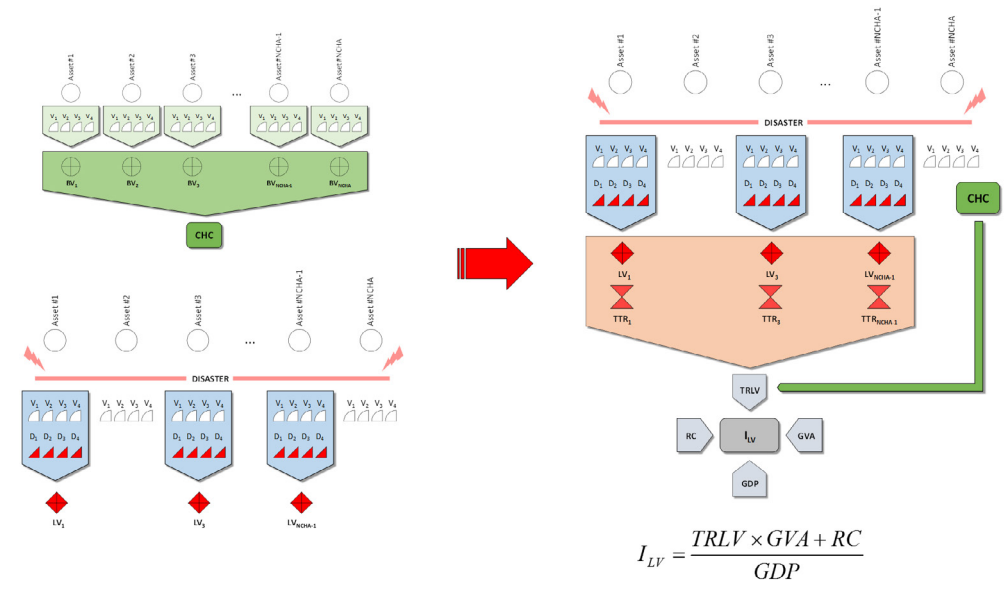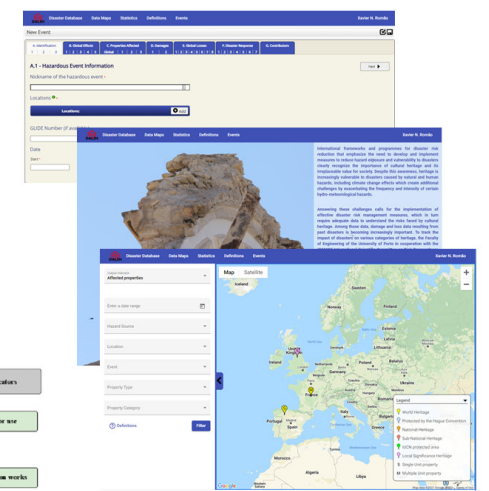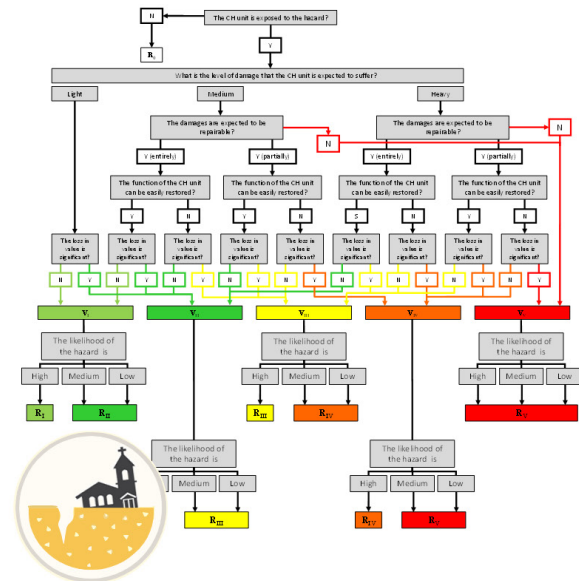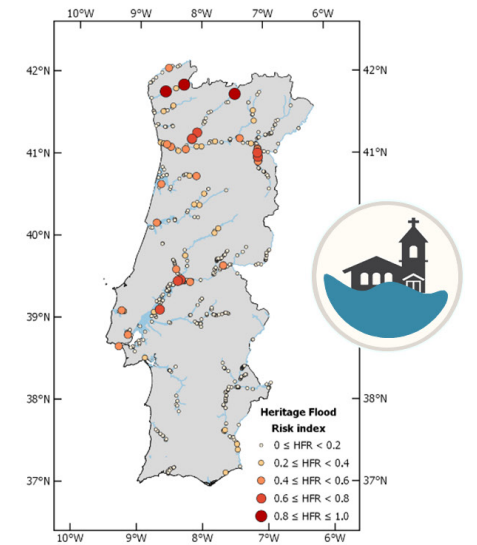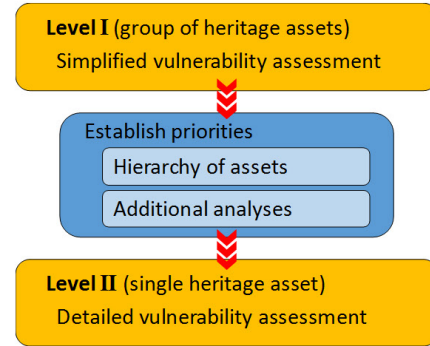
PROCULTHER-NET — Protecting Cultural Heritage from the Consequences of Disasters-Network

Principal Investigator
Xavier Romão

Total funding
22 570€

Source of funding
European Commission

Protecting cultural heritage at risk of disaster is a new challenging frontier for the reinforcement of disaster risk management/civil protection operations. The urgency of adopting a stronger people-centered approach even in this field calls for increased capacities and knowledge to ensure coordination, effectiveness and efficiency at national and European level. A structural link between science and decision makers should be strengthened to provide for knowledge that can help reduce the vulnerability of disaster-prone communities and ensure more sustainable and risk-informed procedures for intervention. PROCULTHER-NET project established a European thematic community on the protection of cultural heritage at risk of disaster to support and complement the efforts made by the European Union to strengthen cooperation between the European Union Member States and the Union Civil Protection Mechanism Participating States in the field of civil protection. Drawing on the extensive network of contacts and technical and operational content built up through past projects, PROCULTHER-NET will consolidate and expand multidisciplinary and risk-based exchange practices in the field of cultural heritage protection in emergency. PROCULTHER-NET also increased the Union Civil Protection Mechanism interoperability standards by reinforcing transfer of know-how and learning processes on the inclusion of cultural heritage protection in disaster risk management. This objective focused on the definition of capacity-development activities through training of trainers/ad hoc training initiatives. Adopting a science-based and bottom-up approach, the identification of cultural heritage-focused capacities will feed knowledge-building efforts and ensure that decision-making processes are more effective and consistent with the progress made in the field of cultural heritage protection in emergency.
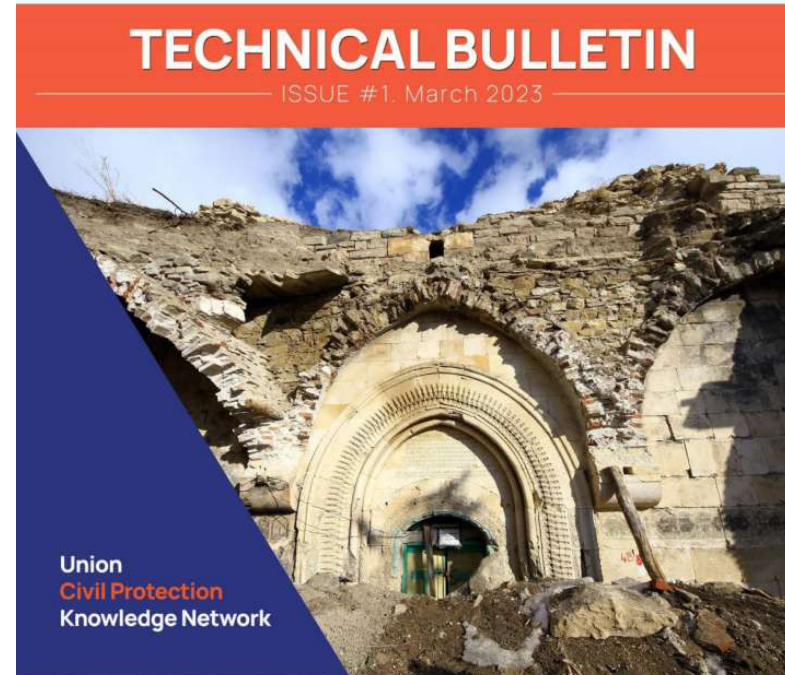
SAFENET - Seismic Risk Assessment for Transportation Networks

Transportation networks are fundamental for the development of the economy of each country, and assume a pivotal role after destructive earthquakes, not only during emergency but also in the recovery and reconstruction phases. Understanding disaster risk and building resilient infrastructure is therefore of critical importance, as highlighted by the Sendai Framework for Disaster Risk Reduction and the United Nations 17 Sustainable Development Goals.

However, there are several obstacles to the incorporation of transportation networks' damage in risk assessment. In this project we propose to develop a novel framework to tackle some of these obstacles and challenges in network analysis, employing state-of-the-art machine learning techniques and big data. These methods will be integrated into a dynamic platform to assess the impact of earthquakes in transportation networks and in the surrounding building stock. The development of the platform will follow an open-source philosophy, and will be co-designed with relevant national and international stakeholders to ensure that the outcomes are usable and useful for risk reduction activities. The developed methods and platform will be built upon openly accessible seismic risk analysis and traffic simulation, and involve well-established communities around these resources. The characterization of the elements comprising the transportation network and the building stock will benefit from the rise of artificial intelligence methods, in combination with open-data from OpenStreetMap. The population dynamics will be modelled using big data from mobile towers, which can be used as a proxy for population density at different times of the day or throughout the year. To demonstrate the applicability and usefulness of this platform, two case studies will be explored considering the district of Lisbon (for a risk evaluation at the urban scale) and the Southern region of Portugal (regional level).
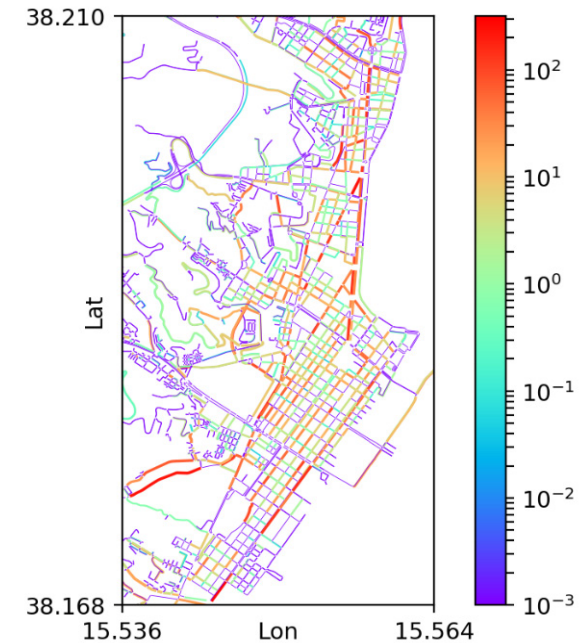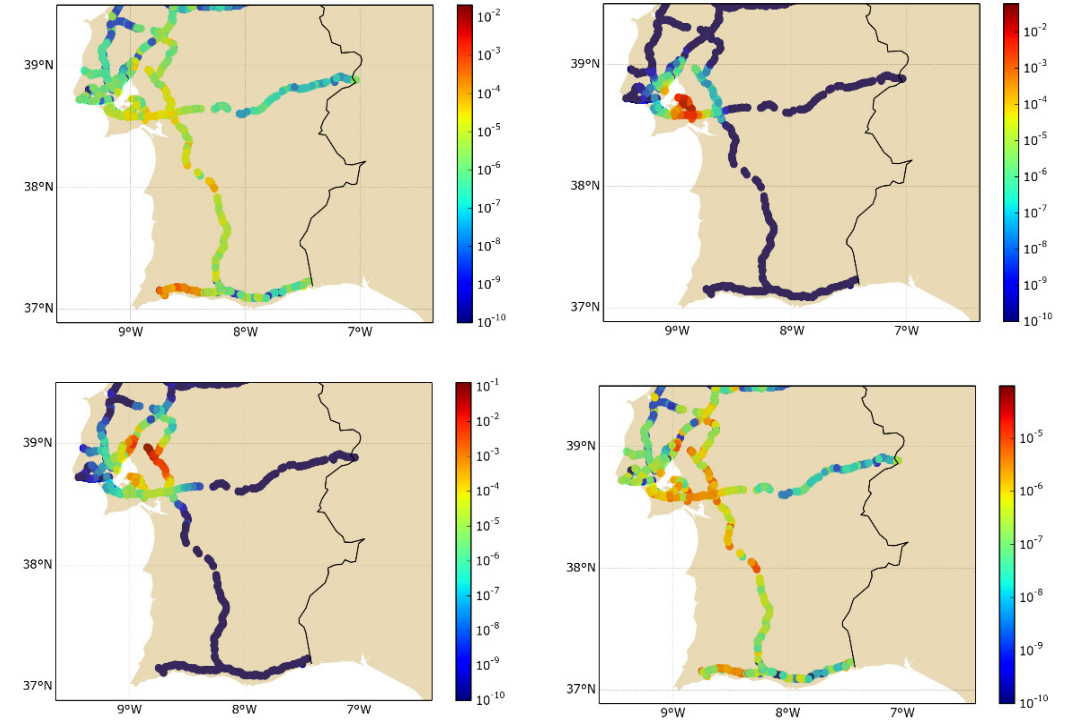
LODE — Loss Data Enhancement for DRR and CCA Management

Principal Investigator
Xavier Romão

Total funding
96 065€

Source of funding
European Commission

The project deals with the practical issues involved with collecting, storing and organizing data related to losses and damages following disasters, given the importance of these data for the development of tools and methodologies for the analysis, modeling and assessment of risks. In this context, the project is developing a data model for damage and loss due to disasters that will establish an information infrastructure that allows recording such damage and loss for multiple sectors and for relevant spatial and temporal scales. The data model that the LODE project will develop will focus on three sectors: critical infrastructures, economic activities and cultural heritage.

Para que serve esta informação relativa às catástrofes?
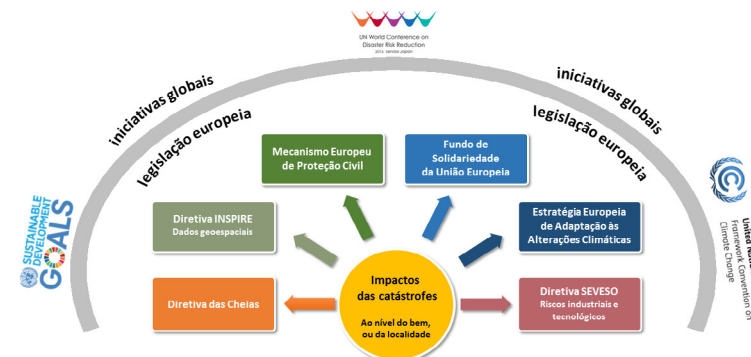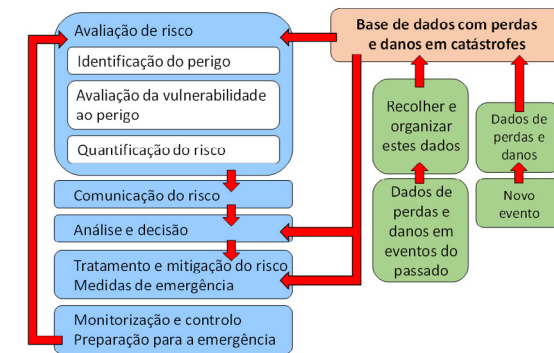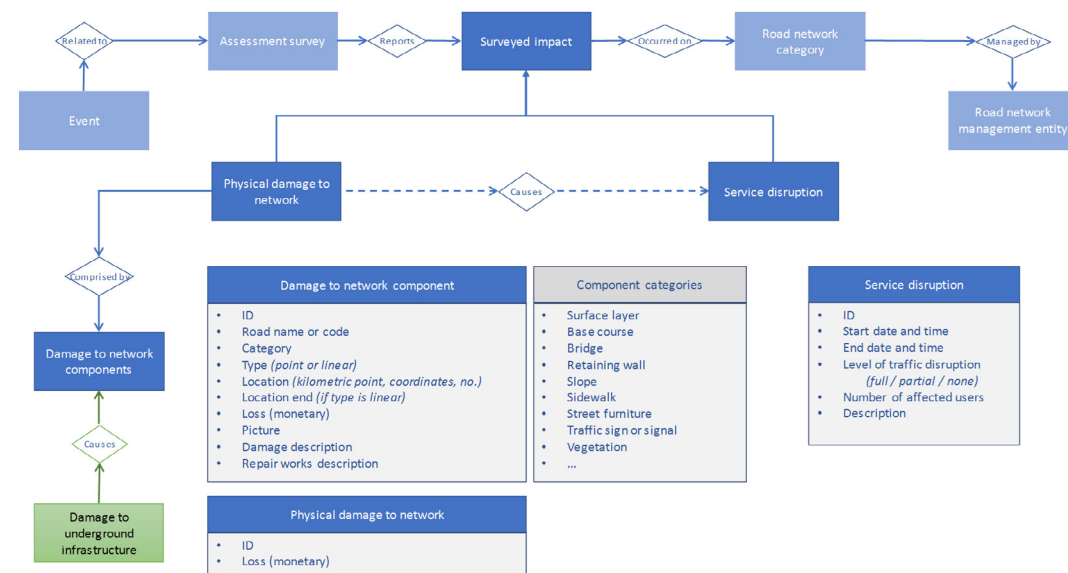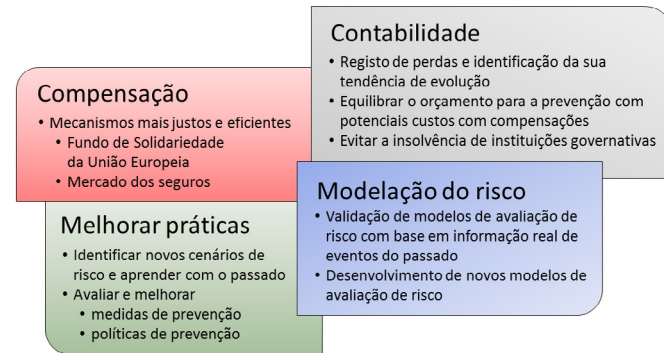
LIQUEFACT — Assessment and mitigation of liquefaction potential across Europe: A holistic approach to protect structures/infrastructures for improved resilience to earthquake-induced liquefaction disasters

Principal Investigator
António Viana da Fonseca

Total funding
531 925€

Source of funding
European Commission

Over the past decade, earthquakes proved to be the deadliest of all European disasters, with almost 19,000 fatalities and direct economic losses of approx. €29 billion. Earthquake Induced Liquefaction Disasters (EILDs) is responsible for tremendous amounts of the structural damages and fatalities; with experiences from recent events giving example of where approx. half of the economic loss was directly caused by liquefaction. Liquefaction is a phenomenon, with previously a low profile until recent earthquake events, in which the stiffness and strength of soil is reduced by seismic activity. With the causes of Liquefaction being known, it is important to recognize the factors that contribute to its occurrence; as well as the resulting hazards. The theory on how to address the subject has been comprehensive, as well as the engineering to reduce its consequences of liquefaction already developed; however, recent findings and advances need to be accurately examined in order to implement mitigation strat-

egies practically. A systematic approach is needed for assessing the possibility of liquefaction on a site, prior to construction, then implementing the most appropriate liquefaction mitigation techniques. However, the variability of circumstances, invariably translates to multiple approaches of implementation, based on the susceptibility of the location to liquefaction, as well as the type and size of structure. The LIQUEFACT project addresses the mitigation of risks to EILD events in European communities with a holistic approach. The project not only deals with the resistance of structures to EILD events, but also, the resilience of the collective urban community in relation to their quick recovery from an occurrence. The LIQUEFACT project sets out to achieve a more comprehensive understanding of EILDs, the applications of the mitigation techniques, and the development of more appropriate techniques tailored to each specific scenario, for both Europe and global.
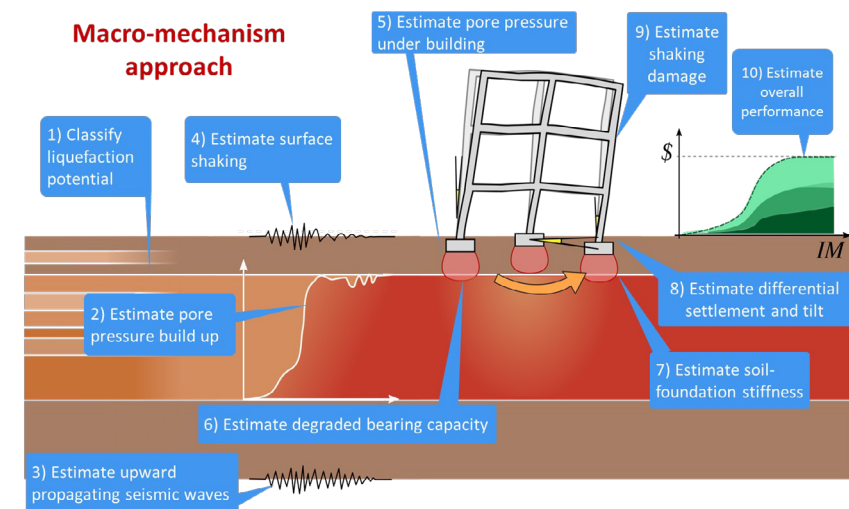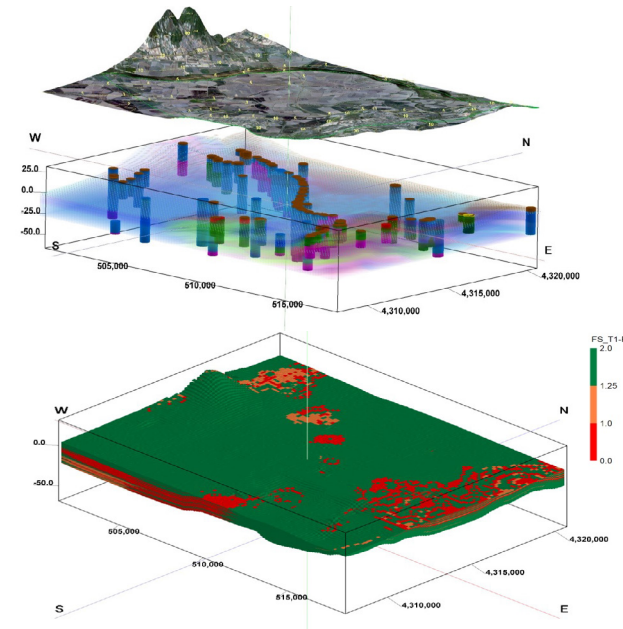
VIPIB — Vibrations induced by pile driving in buildings: an integrated methodology for prediction and mitigation

Principal Investigator
António Silva Cardoso

Total funding
188 608€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Driving piles in the ground generates vibrations that can damage existing equipment and structures and cause disruption to people and activities positioned in the vicinity. The difficulty of predicting these vibrations in many cases limits the applicability of the method, with harmful technical and economic effects. The present project aims to develop, implement and explore a global numerical model for prediction and mitigation of vibrations inside buildings due to pile driving operations. The project provides for the validation of this model by comparing its results with those measured in field experiments, developed specifically within the scope of the project. These small and full scale experiments will also enable a deeper understanding of the complex phenomena associated with the generation and propagation of vibrations caused by pile driving. The research team has consolidated experience in the study of vibrations caused by human activities.
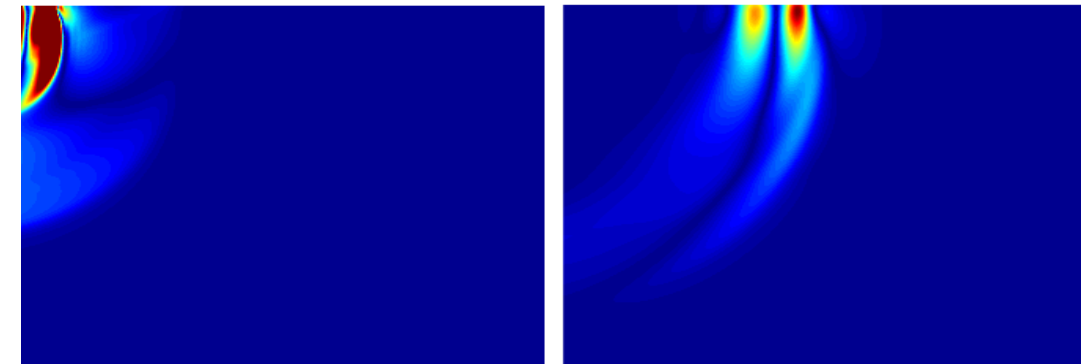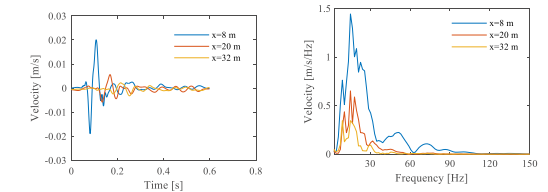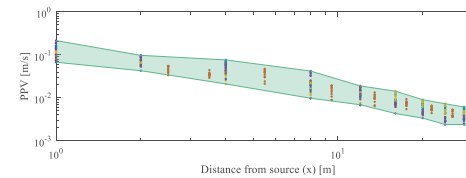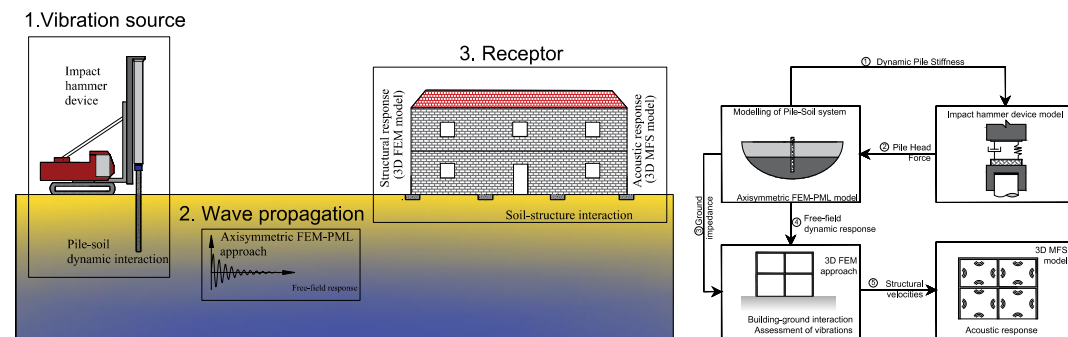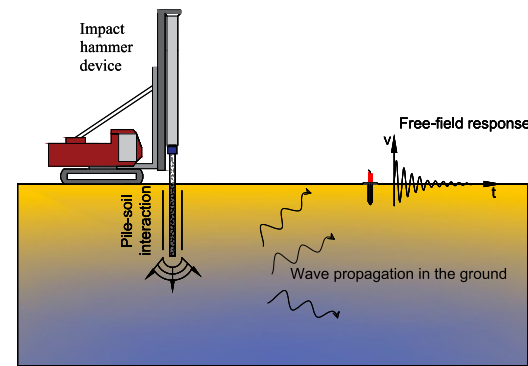
GeoSynergism — Evaluation of Synergic Effects in the Degradation of Geosynthetics

The GeoSynergism project is about the durability of geosynthetics, focusing mainly on the interactions (synergisms or antagonisms) that may occur between the degradation agents of these materials. The study of such interactions represents an innovative and relevant contribution for the development of the knowledge about the durability of geosynthetics (the available studies on this topic consider mostly the isolated action of the degradation agents, not accounting for the possible interactions that may occur between them). The main aim of the GeoSynergism project is to estimate more realistically the long-term behaviour of the geosynthetics and thereby contribute for the improvement of their design methods. For this purpose, GeoSynergism will assess the durability of geosynthetics taking into account the combined action of many different degradation agents: liquids (water, acids and alkalis, saline solutions, and metal ion solutions), thermo-oxidation, ultraviolet radiation and other weathering agents, creep, abrasion, and installation damage. The research strategy of GeoSynergism project consists in (1) expose the geosynthetics to the isolated action of the degradation agents (single exposures), and then (2) expose successively the materials to combinations of two, or more, degradation agents (multiple exposures).The damage occurred in the geosynthetics (during the single and multiple exposures) will be evaluated by monitoring changes in their physical, mechanical and hydraulic properties. Based on those changes, the combined effect of the degradation agents will be compared to the sum of their isolated effects. This way, the occurrence of interactions (synergisms) between the different degradation agents will be evaluated. The results of GeoSynergism project will contribute to (1) estimate with more accuracy the long-term behaviour of geosynthetics, (2) identify and quantify interactions between the different degradation agents of geosynthetics, (3) evaluate if the actual design methods are able to predict correctly the combined effect of the degradation agents and (4) improve the methods for determining reduction factors for the combined action of the degradation agents. Globally, the results of GeoSynergism project will contribute to a better understanding of the durability (and degradation mechanisms) of geosynthetics, taking into account the interactions that may occur between the different degradation agents, thereby allowing a more sustainable application of these materials in Civil and Environmental Engineering.

RESEARCH PLAN

CHARACTERISATION TESTS

DEGRADATION TESTS

DEGRADATION TESTS
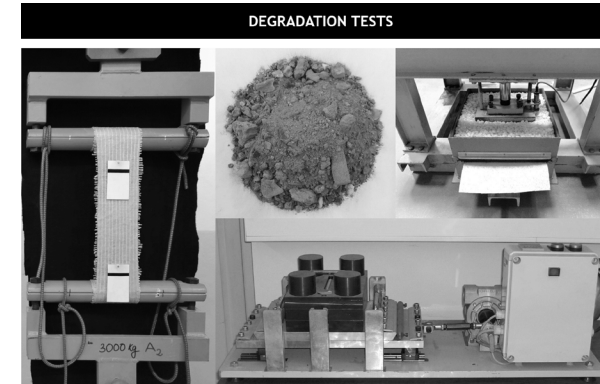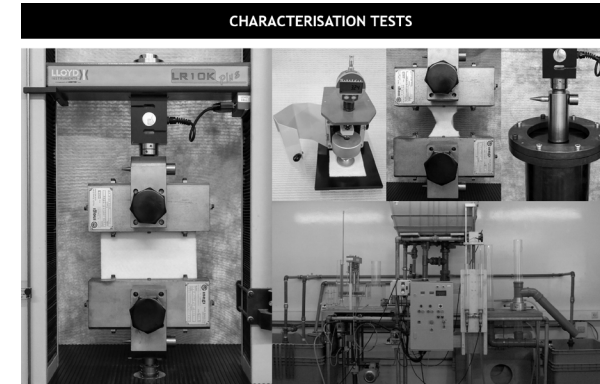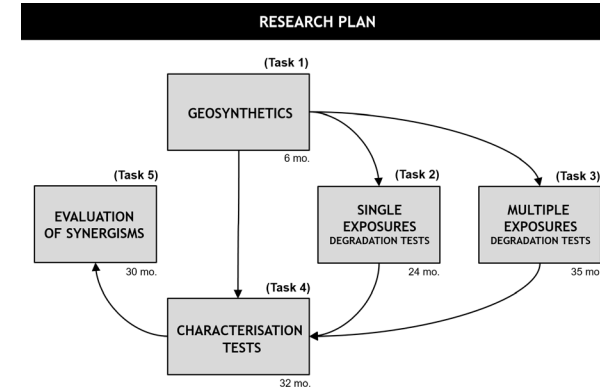
LIQ2PROEARTH — Liquefaction assessment protocols to protect critical infrastructures against earthquake damage

Principal Investigator
António Viana da Fonseca

Total funding
168 060€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Gel-Push sampler
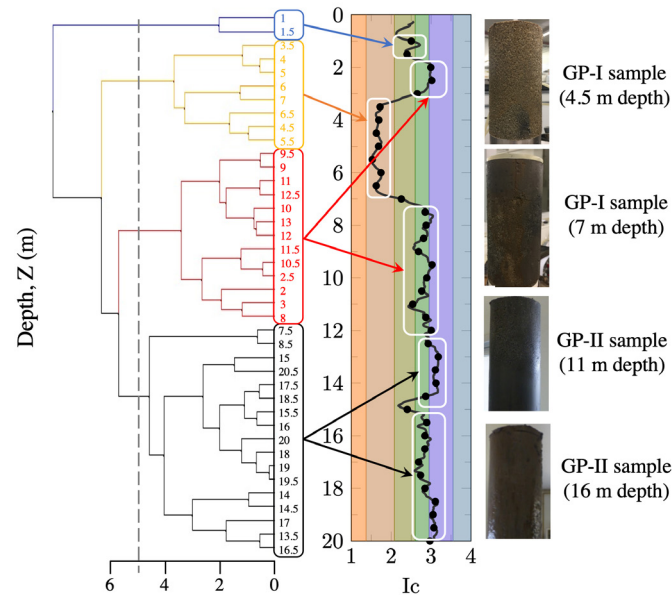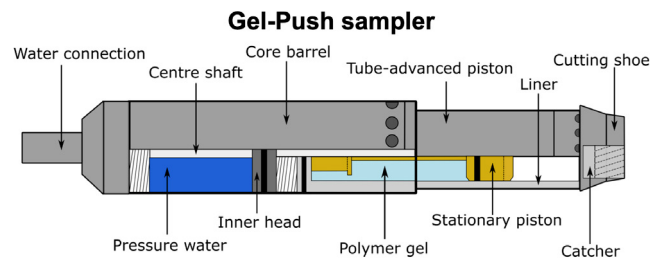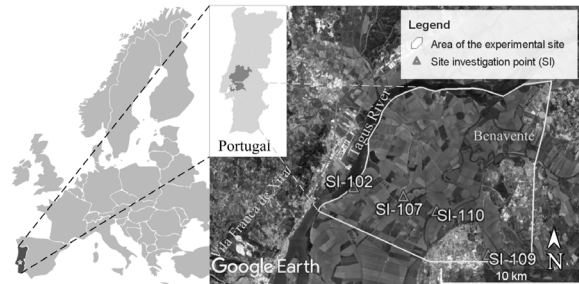
Earthquakes are one of the most destructive natural phenomena. The increasing frequency and severity of seismic activities poses a serious threat to buildings and physical assets located in vulnerable locations, including critical infrastructures (i.e. public buildings, such as government offices, transport stations, terminals, historical buildings and hospitals, as well as buried pipeline network systems and bridges). Soil liquefaction, frequently associated to these events, has been one of the most dramatic and significant causes of damage to engineering infrastructures and human losses, namely recently in the 2011 Great East Japan, in 2010-11 Canterbury-New Zealand earthquakes and in 2012 Emilia-Romagna, Italy. Loss of residential buildings and damage to infrastructures, such as bridges (especially abutment supports), buried pipeline networks (water supply and wastewater systems, gravity pipes, undulation of road surface and relative movement of manholes, failure of joints and connections) severely compromised services and assistance to populations. In Portugal, the centre and south regions, densely populated areas with the highest seismic risk, are laid over loose alluvial sandy deposits, which need to be carefully labelled in terms of risk level zonation. This susceptibility to cyclic mobility and liquefaction has already been identified, yet not systematized, thus justifying research based on in situ and laboratory studies of local sands, silty-sands or even non-plastic sandy-silts, in view of a fundament evaluation of their sensitivity to liquefaction. An inexpensive yet effective protocol is urgently due to increase safety when designing in those areas. There is a need for cost-effective seismic protection solutions that can be economically adopted to safeguard infrastructures and/or residential structures, towards mitigating the impact and effects of seismic events, including the associated damage and fatalities. Portuguese codes still lack a clear approach to liquefaction hazard zonation. The introduction of such techniques would provide guidelines for implementation of such solutions to the EU building code applicable to earthquake-prone regions (Eurocode 8, EN1998). The studies proposed in this project will focus on the definition of practical methodologies useful for areas where funds for more rigorous procedures may not be available. The approach will utilize in situ tests which can clearly identify liquefaction-prone deposits, based on the results treated in explicit indexes, generating a rapid and clear liquefaction susceptibility classification. Experimental sites will be selected after qualitative information on soil state conditions, low density and significant thickness of granular deposits. The evaluation of the ground-shaking hazard will evidence areas where thick, loose/soft deposits likely to amplify and increase the duration of ground motion can be found, and identify areas where seismic risks are strongly associated to liquefaction. Combining the two maps, an integrated liquefaction hazard zonation map will be produced, providing an improved characterization of the soil capacity to resist liquefaction. Recent works from FEUP geotechnical group of CONSTRUCT have confirmed that liquefaction predictability of granular soils can be essentially addressed by Critical State Soil Mechanics (CSSM) theory, both from static/monotonic loading and cyclic loading conditions, but some limitations were identified (fines content, soil fabric, ageing overconsolidation or cementation, stress state and Induced stress path) which will be further addressed in these studies. In situ testing for estimate of the cyclic resistance ratio CRR is quite controversial, with distinct perspectives on the advantages of the available methods based on penetration, dilatometer or pressuremeter test results, or seismic wave analysis from geophysical surveys. Besides being only applicable in the field, except for the latter which can be reproduced in the laboratory, these procedures are mostly semi-empirical, limiting its generalization for an accurate interpretation of soil instability. In order to clarify the reasons for such differences, the experimental program will also associate high-quality sampling; for that, the project aims to implement in Portugal the novel technique of the gel-push sampler;. The collected high-quality samples will be tested in laboratory in advanced apparatuses (cyclic triaxial, cyclic direct simple shear, torsional, with shear and compression wave measurements) to identify some of the factors that control soil behaviour. Numerical modelling of specific site conditions will also be done, based on the fundamental parameters deduced from these tests, confronting distinct approaches to deal with instability, such as Stress-Density (SD), SANISAND, new UPC (Barcelona) and (UCDavies) models, all supported by the international consultants who will be working in the project.

GEOLAB-CENLIMIT — Centrifuge modelling of desaturation for soil liquefaction mitigation

Principal Investigator
Cristiana Ferreira

Funding
Funds for execution of tests in a Geotechnical Centrifuge

Source of funding
European Commission

Extreme natural events, such as strong earthquakes, represent one of the major threats to a safe, resilient and sustainable society. Preparedness for these events must be addressed as early as possible, ideally as part of the design of structures and infrastructures. Earthquakes often induce soil liquefaction, in which its stiffness and strength are dramatically reduced, due to the increase in pore water pressure in saturated loose sand-like materials during seismic motion, resulting on the soil behaving as a liquid. Earthquake-induced liquefaction can cause significant damages in structures and critical infrastructures (i.e. hospitals, pipeline network systems and bridges), being one of the most dramatic causes of human losses. The causes of liquefaction are well known, and the factors contributing to its occurrence and its consequences are increasingly recognised; however, it is urgent to propose effective and site-specific solutions for its mitigation.

One of the most effective and universal tools for the remediation of liquefiable soils is desaturation, accomplished by reducing the degree of saturation in these soils. In this proposal, a 2-week experimental plan will involve the construction of physical models in the geotechnical centrifuge at the University of Cambridge to explore induced partial saturation, by verifying the desaturated cyclic behaviour and validating the improvement of the liquefaction resistance of the soil. The proposed innovative use of P-wave velocity measurements stems from the need to reliably estimate the degree of saturation, allowing for a more precise assessment of the performance and effectiveness of the induced partial saturation technique by air injection. Since these wave measurements are comparable in field and laboratory conditions, this approach offers great potential for replication and practical implementation. The results of this project can be subsequently applied to the analysis of the liquefaction response of critical infrastructures founded in partially saturated soils.

SAFETY — Stability Analysis For Enhanced Tailings storage facilities

Principal Investigator
Sara Rios

Funding
Funds for execution of tests in a Geotechnical Centrifuge

Source of funding
European Commission

SAFETY proposes four centrifuge tests to be performed in one month in DELTARES to analyse the stability of tailings storage facilities (TSF) when the water table rises in the TSF due to heavy rainfall, and/or others factors, like inefficient drainage. Mine tailings are the finer waste material that remains after extraction of the economic part from the mineral ore. Traditionally, tailings are deposited in dams but, due to their high risks expressed in recent catastrophic failures, another approach is being explored concerning the deposition of filtered tailings in stacks. The strength of these stacks will depend on the type of material, degree of saturation and compaction, as well as drainage conditions, effective stresses due to loading and/or excess pore pressure generation requiring effective stress-strain analysis and appropriate constitutive models. In this project, simple slope models are proposed with iron tailings from Brazil characterised in FEUP geotechnical laboratory with advanced tests. The first experiment concerns a homogenous model with loose material where a steady state water flow is established. The aim is to increase the hydraulic gradient to trigger failure. Another experiment will focus on a zoned embankment where the inner part will be in loose state while the outer shoulders will be more compacted. The aim is to evaluate whether the outer structured zone can sustain the undrained failure of the inner zone. These experiments will be repeated replacing water by a viscous fluid to evaluate its effect on the rate of pore pressure generation due to high g conditioning. The tests will be reproduced in advanced numerical analyses to calibrate constitutive model parameters. The optimum parametric protocols will be used to simulate other embankment geometries or ground improvement solutions. The results will be published in relevant journals aiming to optimize stability analysis procedures in such sensitive materials.
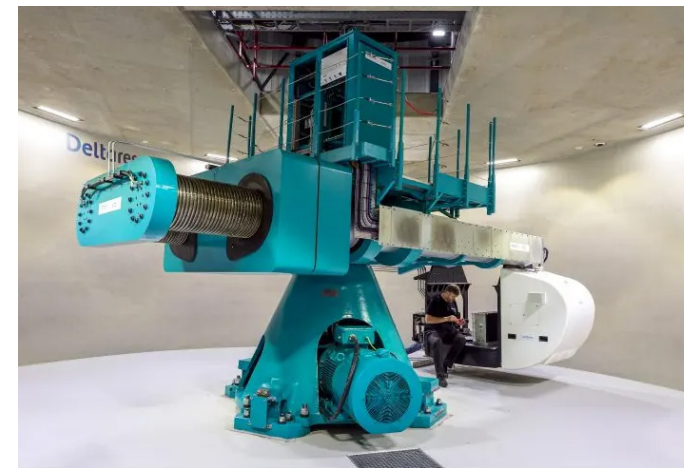
InaWAVE — Innovative approach to wave-based experimental determination of damping of soils

Principal Investigator
Cristiana Ferreira

Total funding
49 997,50€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Seismic events are extreme natural hazards and particularly challenging for Civil Engineering, since these are unpredictable, unexpected, sudden and, although relatively brief in time, potentially very destructive. This means that preparedness for its occurrence must be addressed as as soon as possible, ideally as part of the design of the structures and (or) infrastructures. From the geotechnical engineering perspective, there is even greater uncertainty, given the natural variability and heterogeneity of geomaterials and geological features, combined with the limited knowledge of site-specific seismic response.

It is, therefore, crucial to reliably understand the dynamic behavior of soils, in order to be able to predict the response of the soil mass and to minimize the impact of its deformations induced by the seismic vibration. There are still much uncertainty in predicting soil behavior, especially under cyclic and dynamic loads, mainly due to limitations in the accurate estimate of soil damping, which strongly depends on loading conditions, in terms of frequency, shear stresses and strains.

Since soil damping has not been widely studied, due to its complexity and difficulties in its measurement and quantification, its influence on the response of soils and structures is poorly understood. In fact, the current methodology for estimating this key parameter in research and design is still based, in most cases, on the use of typical values, available in the literature, since laboratory determination requires relatively rare equipment, such as resonant column. The site-specific determination for each soil, taking into account the state and stress conditions, is therefore an important, necessary and urgent step.

In this context, this project aims to contribute towards a better understanding and more accurate characterisation of stiffness and damping parameters for soils, especially under seismic or cyclic loading. To this end, this project proposes the design, development, validation and calibration of an innovative technological tool that will allow the laboratory determination of soil damping, using bender elements (BE). The definition of the experimental protocols for the simultaneous determination of the shear modulus and damping ratio, including the implementation procedures in current geotechnical tests, is a key contribution of this exploratory research project.

Some proposals for the determination of damping using BE have been reported in the literature, with limited success. The main obstacle in these proposals lies in the fact that in BE testing, only the generated signal and the received signal are known, and it is not possible (until now) to distinguish the actual contribution of the soil, which makes it impossible to accurately characterize the soil. This can be overcome with the use of new laser monitoring techniques of the BE response in different scenarios. These new techniques employ laser measurements on the BE itself to assess the transducer deformations for a wide range of frequencies and in different media (in air, water and other fluids and even in transparent soil specimens). These new advancements have been made at the University of Waterloo in partnership with LabGEO FEUP, so this project is intended to introduce a new practical application, which is the accurate determination of soil damping.

Supported by this advanced soil characterisation tool, it will be possible to accurately and reliably describe the response of the soil under cyclic or dynamic loads, for a more consistent geotechnical characterization of the soil profiles in susceptible areas, and consequently a more accurate estimate of local seismic amplification will be accessible. This is fundamental for site-specific assessment of liquefaction susceptibility and subsequent prediction of soil-structure interaction. This information can then be applied to the selection of effective liquefaction mitigation solutions, to safeguard new and existing structures and infrastructures to earthquake-induced liquefaction events, with clear impact in the protection against seismic hazards.

INPROVE — INnovative solution for sustainable stabilisation of tailings deposits facing climate change

Incremental displacements |Δu| (scaled up 20,0*10³ times)
Maximum value = 0,1978*10⁻³ m (Element 432 at Node 4066)
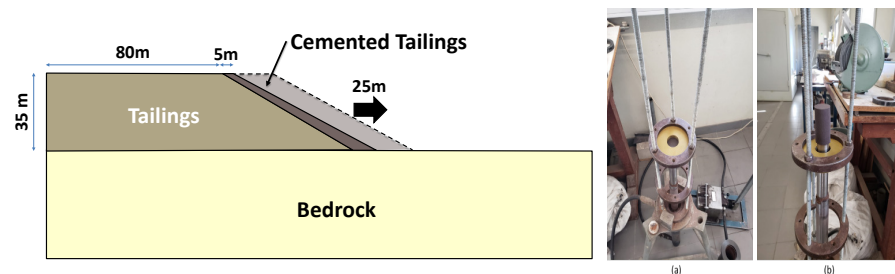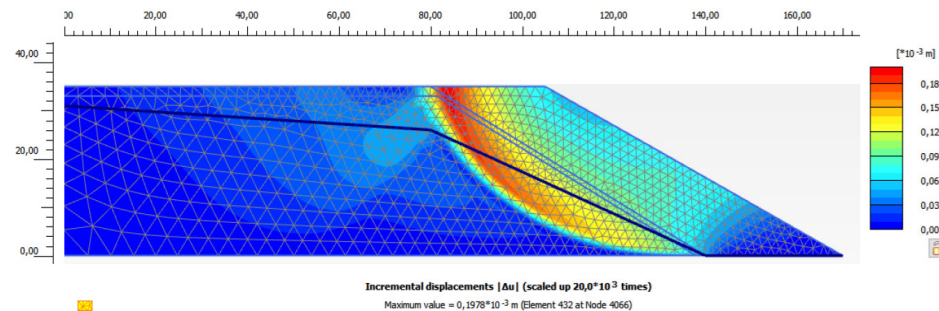
The mining industry is a fundamental pillar of modern society, providing the minerals for energy transition and digitalisation that comprise the European plan to recover from the COVID-19 crisis towards green and digital industries. This is in line with Portugal aspiration to explore lithium. The supply of mineral raw materials requires an adequate management of tailings, the fine material discarded after ore extraction, traditionally disposed in dams raised by tailings hydraulic fill. The increasing number of catastrophic accidents in tailings dams demonstrates that the stability of these structures constitutes a geotechnical engineering challenge for which an urgent solution is needed. An alternative deposition in dry stacks has been used compacting filtered tailings (with less water) in massive embankments. However, accidents were observed in these structures during heavy rain periods, indicating that more robust solutions are needed especially in a climate change scenario.

INPROVE proposal is to build structural zones with cemented filtered tailings to improve the stability of dry stacking embankments or to reinforce existing facilities at risk. This is very important: in new facilities, to re-mine existing facilities with historical accumulated resources, and for remediation and closure plans of existing facilities. These latter often include the reanalysis of potential vulnerability and eventual stabilisation or improvement with structural zones (usually not cemented). Due to climate change, storms are becoming frequent and stronger, turning these structures even more instable. For these reasons, advanced hydromechanical analysis are required with constitutive models capable of simulating the evolution of the material during construction history and the softening behaviour associated to the tailings brittle response. Up to now, these advanced analysis were mostly used to identify the causes of accidents rather than for design purposes. Considering the carbon footprint of Portland cement (OPC), a more sustainable binder generated by the alkaline activation of industrial by-products (AAB) is highly convenient. However, conversely to OPC, there is no rational methodology to define the mixture dosage in soils stabilised with AAB which has prevented its large scale application. To address these challenges, INPROVE provides the following innovations:

i) an integrated solution that comprises not only the material development and binder optimisation but also a rational methodology to define the best mixture dosage taking into account the tailings in situ water content, density of the treated layer after compaction, and required mechanical performance at a given curing period.

ii) a systematic approach to link laboratory characterisation with advanced constitutive model parameters capable of reproducing the post-peak behaviour associated to bond degradation. This is important to numerically analyse the influence of the structural zone on the tailings deposit stability.

iii) design charts for dry stacks relating the mixture dosage and the thickness of the stabilised berm for a given embankment height and a typical slope angle.

The approach is based on a mixture index that includes the effect of binder dosage and mixture compaction degree. After obtaining a clear relation between this mixture index and the mechanical behaviour of the material, this index will be related to constitutive model parameters. For this purpose INPROVE comprises: i) statistical analysis based on design of experiments (DoE); ii) advanced laboratory characterisation on the stabilised tailings; iii) hydromechanical numerical analysis in models previously calibrated with centrifuge tests.

The objective is to establish a simplified calibration procedure relating mixture dosage, mechanical behaviour and constitutive model parameters for tailings stabilised with AAB. This is expected to have a major impact on a wider use of sustainable AAB, enabling the numerical simulation of tailings storage facilities with structural stabilised berms to reinforce and contain possible localised liquefaction failures occurring on the unreinforced area.

GEOCLIMAT — GEOtechnical CoLlaboratIons, Modelling and Advanced Testing to face climate change

Principal Investigator
Sara Rios

Total funding
14 957,25 €

Source of funding
Mecanismo Financeiro
do Espaço Económico Europeu

This initiative aims to exchange advanced knowledge regarding experimental geotechnical testing and physical modelling between Portuguese and Norwegian partners to improve engineering design, towards increasing the resilience of critical infrastructures against adverse conditions induced by climate change. The digital and energy transition requires more reliable and sustainable solutions to manage waste materials as by-products in construction and mining operations, such as tailings storage facilities. In turn, renewable energy production facilities (such as wind farms) are in high demand and frequently constructed offshore in complex geotechnical scenarios. Extreme climate events induce geohazards, such as storms, flooding, and landslides, which pose additional challenges to the design and risk control of these geotechnical infrastructures, since any structural failure would result in catastrophic economic and environmental consequences.

The main objective is to exchange scientific knowledge and technical know-how regarding experimental methodologies for the characterisation of sensitive geomaterials. This work will target advanced geotechnical tests (including field and laboratory tests) towards the calibration of constitutive parameters, and physical modelling using centrifuge tests to study the associated geotechnical structures in order to optimise their design when subjected to climate geohazards. The other objective is to transfer the knowledge generated in this project to master and doctoral students of geotechnical post-graduation programs (FEUP and OsloMet). This focus on sensitive soils is innovative as existing approaches were developed for clean sands and clays. It is expected this initiative can strengthen the research links between Portuguese and Norwegian institutions (FEUP, NGI and OsloMet) promoting future research projects and education activities. This is also a way of disseminating the results of ongoing projects among these institutions.

M4WIND — Monitoring, Modelling and Machine learning for Managing the operating life of wind farms

Principal Investigator
Filipe Magalhães

Total funding
104.702,64

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The key role of Wind Energy in fighting climate changes and improving Europe's energy security is consensual. Nowadays, wind meets 16% of Europe's electricity demand and the EU commission plans having wind as half of Europe's electricity source by 2050. This ambition, together with the goal of electrification of the European economy, will imply raising the actual capacity of 220GW to 1300GW.

In this process, the installation of new, more powerful, wind turbines (WT) should be combined with a wise management of the existing infrastructure, with a considerable number of WT soon reaching the end of their design life. Knowing that the moment of decommissioning of WT major components is driven by fatigue, the topic of operating life management of WT, associated with fatigue life consumption, is of extreme importance.

Considering this background and the available research infrastructure, the major goals of the project are the accurate characterization of past, present and future fatigue stresses (or fatigue consumption indexes) on tower and blade sections and the development of tools to enable a smart management of the operating life of these critical structural components. The foremost novelty of this project is the combined use of 3 Major tools:

M1 – Monitoring – the project team has a large experience in structural monitoring of WT, unique data-bases of experimental data (ongoing monitoring projects on 7 onshore WT and on one of the largest floating WT) and innovative ideas for the development of customised monitoring devices, not only to characterise stresses but also to monitor variables that can early detect malfunctions with impact on fatigue loads. So, this will be the solid base for the methodology development and validation.

M2 – Modelling – since measuring all relevant quantities on site is economically prohibitive, the development of digital twins calibrated with measurements is crucial to support the extrapolation of the structural responses to other (non-observed) operating scenarios and to non-instrumented sections. These will be also fundamental to support the creation of surrogate models that can simplistically model the impact of operation anomalies (such as foundation problems, rotor imbalances and yaw misalignments) on fatigue load spectra.

M3 – Machine Learning – this includes the development of several black-box models to convert limited monitoring time-histories into parameters for fatigue evaluation of full structural elements, but also interpretable hybrid models that combine monitoring data with numerical models. Advanced machine learning models will also enable handling large populations of WT and assess the fatigue of fleets using selected more instrumented WT.

The 3Ms will allow estimating the consumed fatigue life of full wind farms with minimal instrumentation, accurately quantify the impact of key factors on fatigue loads and open the path for the fourth M, the Management of the operating life. In this topic, the ambition of the project team is the creation of procedures to influence the future rate of fatigue consumption of the WTs of a specific wind farm, with manipulations on the WTs control system (rotor torque and blades pitch laws as a function of wind characteristics, namely speed, turbulence and direction).

To deal with this very ambitious plan, a multidisciplinary team from 4 institutions was set: two engineering faculties, FEUP and IST, an interface institute of FEUP, INEGI, and an industry partner which owns and operates over 140 wind farms (2.6GW).

DAM_AGE — Advanced Online Dynamic Structural Health Monitoring of Concrete Dams

Principal Investigator
Álvaro Cunha

Total funding
81 384€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The Project aimed at developing an advanced online dynamic SHM system for concrete dams (demonstrator), involving the following main objectives:

- To evaluate and improve the level of accuracy provided by OMA testing applied to concrete dams with different typologies and characteristics, identifying the most suitable technical requirements for measurement devices (sensors and digitizers), and analysing the performance and overcoming limitations of state-of-the-art stochastic modal identification techniques by developing comparisons with results achieved by accurate forced vibration tests;
- To consolidate the development of robust and innovative OMA based SHM software and hardware specifically designed for long-term monitoring of massive concrete dams, enabling the accurate online tracking of the time evolution of the most relevant dynamic properties (modal parameters), the correlation with environmental and operational factors (e.g. water level in the reservoir, temperature, turbines operation) and the statistical removal of these influences, using modal parameters changes for the evaluation of novelty indexes and application of innovative damage detection techniques;

- To implement and manage an efficient OMA based SHM system in a new Portuguese double curvature arch dam under construction (Baixo Sabor), making feasible its long-term dynamic monitoring and health condition assessment and creating a high quality data digital repository including both raw data and relevant structural information automatically extracted in a online basis;
- To develop a sophisticated experimentally calibrated numerical modelling of the dam-water-foundation system enabling to get not only a correct physical understanding of the dam structural behaviour, particularly under significant variations of the water level in the reservoir (since the first filling) and annual temperature, but also allowing the definition of appropriate alarm levels for SHM purposes;
- To implement these alarm levels in the dam SHM system and check the feasibility of early detecting small structural damage using the developed OMA based SHM software.
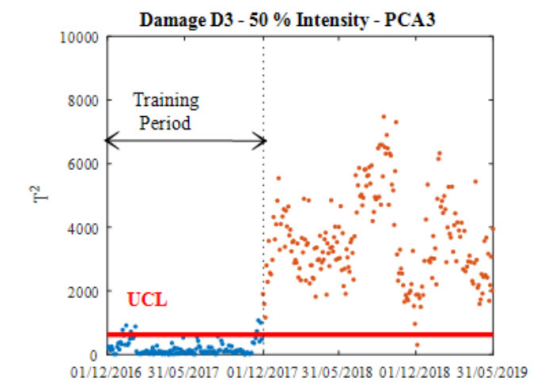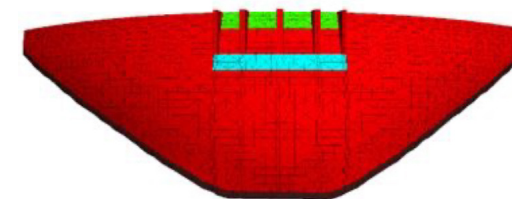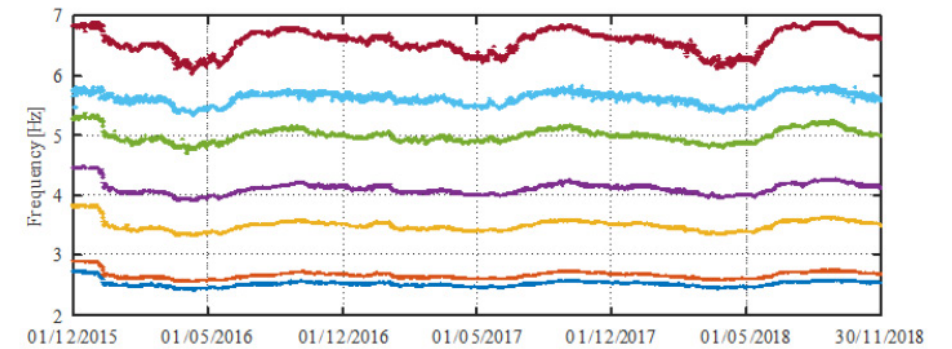
WindFarmSHM — Development, validation and optimization of monitoring strategies for the structural condition of onshore and offshore wind farms

Principal Investigator
Filipe Magalhães

Total funding
135 121€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Portugal electricity demand is covered in 24.5% by wind energy, which is produced by more than 2500 wind turbines (WTs). Several European countries present equivalent figures. The management of this asset can strongly benefit from the development of cost effective monitoring strategies. Furthermore, it is crucial to prepare the scientific community and the industry for several challenges, such as the evaluation of the need of replacement of WT components at the end of their design life (WTs were designed to operate 20 years and the installation in Portugal started 21 years ago) and the installation of offshore WTs in high deep waters (as it is the case of the Portuguese shore) using innovative floating solutions. The extension of the life span of the exiting WTs, the possibility of the reducing insuring costs by reducing the operation risk through monitoring and the possibility of expanding the capabilities for extracting energy from offshore winds, will certainly contribute to increase the competiveness of this energy source. This proposal aims the development, implementation, validation and optimization of new methodologies to continuously assess the structural elements of WTs: tower, blades and foundation (bottom fixed or floating). The monitoring strategy to be proposed will be designed to be applied in the context of a wind farm, using optimized instrumentation layouts at a subgroup of WTs and taking profit from the data provided by the acquisition systems already available in all the WTs (the SCADA system that characterizes the wind at each WT and its operation parameters) for the use of extrapolation techniques to assess all the WTs of the same wind farm. The research project will include the simultaneous monitoring of 3 WTs of an onshore wind farm, comprehending accelerometers, strain gages and clinometers, distributed in the blades, tower and foundation, and the development of numerical models for the generation of artificial experimental data for floating WTs. The data processing will be based on the continuous evaluation of the parameters that drive the structure dynamic behaviour (vibration frequencies and damping) estimated from the structure response to ambient excitation (wind, waves, currents, soil vibrations) and advanced statistical modelling, having in mind two main goals: detection of stiffness reductions motivated by the appearance of damage and evaluation of the remaining fatigue life of the main structural components. The project team will include researchers from the Laboratory of Vibrations and Monitoring of FEUP (ViBest), well known at international level due to its research in Dynamic Testing and Structural Monitoring, from INEGI (an interface institute of FEUP), with a large experience on blades structural monitoring, and from WAVEC, with strong expertise on the numerical modelling of floating WTs.

SOS — WindEnergy

Principal Investigator
José Correia

Total funding
41 804€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

North Sea - Norway

Leixões - Portugal

Metocean Data Analysis

Site

STEP 01
METOCEAN
DATA ANALYSIS

STEP 04
REVENUE
OPTIMIZATION

oil platform — wind turbine

retrofit

Reliability

Life

t_0 t_1

t_2

STEP 02
STRUCTURAL
MODELING

STEP 03
LIFECYCLE
EVALUATION
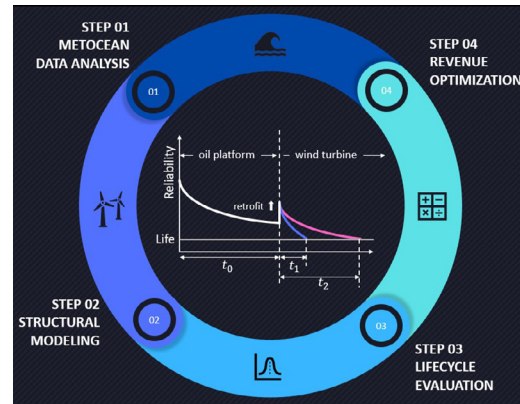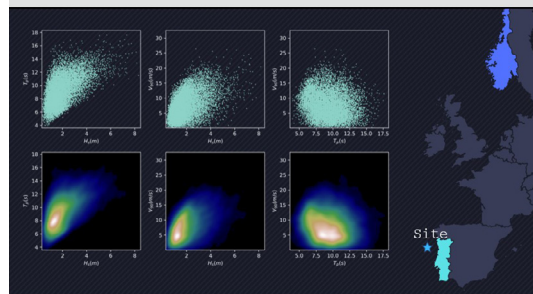
Lifecycle Evaluation

The Earth Planet is roughly composed of 29% of land and 71% of water, where approximately 97.5% of the water corresponds to seas and oceans. Yet, seas and oceans are the planet's least explored resource. In 2010, the European Science Foundation's Marine Council projected that, by 2050, Europe will supply up to 50% of its electricity needs from marine renewable energy, more precisely from wind energy, wave energy, etc. Clearly, harnessing offshore renewable energy will present both opportunities and challenges for the world and, in particular, for Portugal, as the Portuguese and Azores Sea comprises a significantly large area in Europe.vIn a recent study, a group that included members on this proposal; research team outlined a procedure for the requalification of offshore platforms that had been originally designed for extracting natural gas in the Adriatic Sea. After the underground resource has been depleted, these fixed platforms (termed jacket platforms), often sited on sandy sea floors and with low water depths, can be extracted and moved to another location. The work of the research group proposed systematic ways to convert these platforms to be used as support structures for offshore wind turbines. Their proposal was detailed enough to allow efficient evaluation in the initial design phase and for tender design, even when limited metocean (meteorological and oceanographic) information was available for the planned site. The tool they developed was sufficiently detailed but simple to allow systematic structural analysis of the jacket structure and the retrofitted wind tower configuration. Customized offshore wind turbines can be, in this manner, selected with consideration for the wind resource as well as accounting for the available structural integrity including its age and remnant fatigue capacity. Portugal is a leader in offshore wind energy proof-of-concept testing, including for new floating concepts. For instance, in 2011, a full-scale 2 MW floating wind turbine platform was deployed 5 km off the coast of Aguçadoura, Portugal. This platform was completely assembled onshore before it was towed 400 km along the Portuguese coast from its assembly facility in Setubal. To date, the system has produced in excess of 16 GWh of electricity, delivered by sub-sea cable, to the local grid. The IR (Dr. José António Correia) and his team at FEUP (CONSTRUCT & CIIMAR research group) have a wealth of experience in the domains of marine renewable energies, offshore, coastal and port engineering, as well as, design of offshore structures including fatigue analysis criteria. The UT-Austin team will be led by Professor Lance Manuel, who has worked for many years, on problems related to the safety and reliability of fixed and floating offshore platforms, offshore wind turbines, and wave energy converters. His group's main thrust is directed toward better understanding the dynamics of offshore structures, and on uncertainty propagation from the environment through system response and to design. Prof. Manuel is currently the Editor-in-Chief of the ASME Journal of Offshore Mechanics and Arctic Engineering. UT-Austin's efforts in research related to the offshore oil and gas industry began in 1988 with funding from the National Science Foundation, which helped found the Offshore Technology Center (OTRC). This center, created to conduct basic engineering research and develop systems for the economical and reliable recovery of hydrocarbons at ocean depths of 3,000 feet or more, achieved a leadership role in cutting-edge research on critical elements of the deep-water production problem. Together, the two teams will bring important synergies toward addressing the problem of how to safely and responsibly use or reuse existing sites and systems in place for future offshore wind energy generation. The outlined SOS-WindEnergy project will involve the following tasks: I) Review of metocean data and fatigue approaches for offshore structures; II) Feasibility assessments of specific support structures and foundations using metocean data; III) Experimental fatigue evaluation of typical welded joints in offshore jacket platforms; IV) Fatigue performance evaluation of platforms for offshore wind using stochastic simulation; and V) Dissemination activities.vIt is anticipated by the research team that this proposed work is intended as a pilot study for planned reliability analyses of decommissioned jacket platforms and consideration for their future use in wind energy generation in an offshore environment. The benefits to the environment are obvious; such reuse plans reduces waste and the intended future use also contributes to cleaner and more responsible energy generation and less harm to the environment.

Dyncatline — Monitoring and Analysis of the Dynamic Behaviour of the Cable/ Tower System in High Voltage Overhead Transmission Lines under Wind Excitation

Principal Investigator
Elsa Caetano

Total funding
155 352€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The main objective of the Project is the experimental and numerical characterisation of the dynamic behaviour of the cable/tower system in high voltage OverHead transmission Lines (OHL), in order to improve the current design practice regarding wind effects on cables (conductors) and towers. This purpose has been defined from the understanding that: •Despite the high degree of standardisation reached at international level in the design practice of OHL, important uncertainties are still present related with the characterisation of wind loads, of the structural behaviour of the conductor/tower system and of the dissipation capacity of the devices used commonly to prevent and mitigate vibrations. The fact is that the most recent European code {1} provides almost no consideration respecting vibration issues; •There is lack of full scale data, which is consequence of the difficulty in instrumenting powered lines. Although laboratory tests have been established along the years to overcome this limitation, the transfer into practice of experimental results obtained on small scale physical models may not be straightforward or even valid; •Incidents and failures in OHL are still too frequently reported. In a recent survey at national level {2}, two particular types were detected: those related with damage of conductor wires and fittings, caused mainly by wind vibrations; and the ones involving the collapse of towers under extreme meteorological events. The present proposal addresses the exposed questions using a methodology combining the full scale instrumentation of an OHL with laboratory tests and a numerical modelling of the ensemble tower/conductor. Using the opportunity created by the deactivation of an OHL in Portugal, a modern monitoring system based on

fibre optics sensors, anemometers and accelerometers, will be installed on one conductor and one tower in order to monitor the dynamic behaviour prior to and after installation of Stockbridge dampers at different points along the conductor. This system will include the development of an innovative layout for efficient fixation of the fibre optic sensors at height. Complementarily, a non-contact device based on the microwave interferometer will be used for validation of the installed instrumentation system and for measurement of deflections. The collected database will be analysed in order to characterise buffeting effects on the conductor and detect episodes of Aeolian vibrations. Data will be further used to identify damping and calibrate numerical models addressing the cable/tower interaction. Laboratory tests and numerical simulations will be conducted with the purpose of defining an optimal methodology for assessing the required amount of damping and the location and distribution of dampers to mitigate Aeolian vibrations. This research, which was agreed and is supported by the National Energy Agency (REN), will be carried out mainly by a team of the Laboratory of Vibrations and Monitoring (ViBest) of FEUP, whose activity has been in the frontline of research in Dynamic Testing and Structural Monitoring of large Civil structures at the international level during the last 15 years. This is evidenced both by the involvement of ViBest (www.fe.up.pt/vibest) in a significant number of related European and national research projects, and by the participation in important consultancy projects, as the dynamic tests of Millau Viaduct or the Humber Bridge {3}, the continuous dynamic monitoring of the Coimbra footbridge, equipped with TMDs {4}, or of Infante D. Henrique bridge {SP1}.
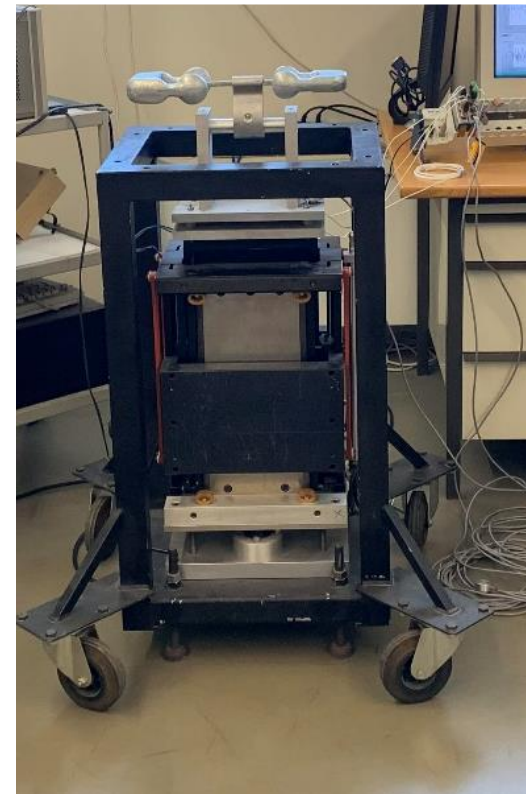
SD Poles — Steel and Dampers for Poles

Principal Investigator
Rui Carneiro Barros

Total funding
326 348€

Source of funding
Agência Nacional de Inovação S.A.

The Project Steel and Dampers for Poles (SD Poles) aims to create new technical and scientific knowledge to develop and conceptualize new solutions of tubular metallic structures capable of overcoming the current limitations of the state of the art regarding the dynamic actions generated by wind and car crashes, corresponding to the concepts of Vortex Shedding and Passive Safety. In this context, this Project will focus its R&D on 3 levels: 1.Viability and technical impact of the incorporation of high strength steel 2.Assessment of new damping methods 3.Analysis of new forms of the base plates built-in the structures and of the corresponding securing methods and fixation systems (relevant in high-dimensional structures, as it increases bending moments and reduces the axial loading). Accordingly, and as a result of this R&D effort, Metalogalva intends to introduce in the market new products, resistant and technically robust to Vortex Shedding and Passive Safety: high-dimensional svelte structures with reduced visual impact; structures with passive safety characteristics using differentiated welding processes; tubular metallic structures with extremely thinned thickness but resistant in superior heights ;and new stamped flanges and respective securing methods, with a positive contribution to address the abovementioned concepts. In order to fulfill the R&D challenges inherent to this Project, Metalogalva and FEUP established a consortium, creating a R&D team with broad technical skills for the exploration of new materials and methodologies, as well as for the creation of new technologies and/or tools, in order to develop new products capable of addressing and anticipating markets? needs and overcoming the lack of technical and scientific knowledge in these areas. In the event of a successful outcome, the new products will have a marketable and international nature, as they will stand as an absolute innovation in relation to the current market solutions.

BEIS — Bridge Engineering Information System

Principal Investigator
Filipe Magalhães

Total funding
151 678€

Source of funding
Agência Nacional de Inovação S.A.

BEIS project aims at researching, developing and validating under real conditions of use a modular Information system which, by incorporating and combining economic and financial tools, analytical and numerical tools, structural analysis tools, construction management tools, statistical tools and heuristic and Machine Learning and Artificial Intelligence tools, will allow to deliver in just a few hours and automatically a valid preliminary and technically updated budget for a bridge. Plus, and in parallel with the budget preparation, the system will assess the carbon footprint of each technical solution. Thus, BEIS system addresses the main gaps within the process of preliminary study and budgeting in bridge engineering, namely the enormous consumption of internal resources, the extended deadlines that directly and negatively impact the project development / decision making process, and, finally, the limited range of technical solutions considered, systematically limited to the technicians knowledge. In compliance, a highly qualified and multidisciplinary consortium was created, bringing together the core competencies and necessary experience to achieve the proposed objectives and deliver a cutting-edge technological solution to the market: BERD (Consortium Leader), Faculty of Engineering of the University of Porto, Faculty of Sciences and Technology of the University of Coimbra, and SimpleAxis. The project is based on the execution of an integrated Activity Plan, composed of 7 complementary activities that will run for 24 months period, foreseeing for this purpose a total eligible investment of 1.179.589,14 €.
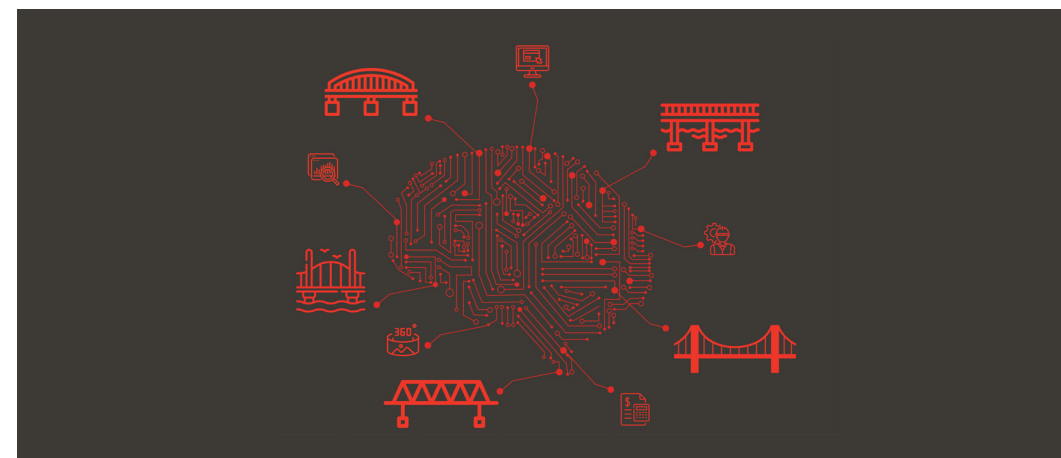
S4Bridges — A smart approach for the maintenance of existing bridges

For the efficient management of the built heritage, particularly in view of the existing bridges, the structural health monitoring offers great opportunities. Therefore, throughout the remaining life of the structures, their behaviour can be followed and their performance degradation can be characterized, allowing for an efficient condition based plan of maintenance interventions whenever necessary. The monitoring and diagnosis automation, including the data gathering, the accurate assessment of the structure condition, and the generation of warnings when structural damages are detected, is the basis for the concept explored in this project of smart structure applied to existing bridges. Experimental techniques and numerical models are combined in this project. The experimental techniques are responsible for measuring the mechanical, physical, and chemical parameters that best reflect the performance of the structure. The numerical techniques are accountable for analyzing the data in order to detect changes in the structure behavior, evidencing the occurrence of damages and, if possible, locating them and quantifying their severity. Regarding the numerical component, the development and application of algorithms for damage detection are proposed. Performance indicators will be processed and analyzed considering the response of the structure, in terms of static and dynamic components, excited through the different environmental and operational effects naturally involved. Different data-driven methodologies will be explored and combined to detect behavior changes. In the end, the processed information should be timely available through a minimum number of representative indicators. The proposed methodologies will be, firstly, tested and characterized experimentally, in the laboratory, using a representative experimental model. In a second phase, the methodology will be applied in a real bridge that is intended to work as a pilot project in demonstrating the valences of smart structures. In this application are integrated researchers from the R & D Unit - CONSTRUCT - Institute of R & D in Structures and Construction, involving Instituto Superior de Engenharia do Porto (ISEP) and Faculdade de Engenharia da Universidade do Porto (FEUP), with expertise in complementary project areas.
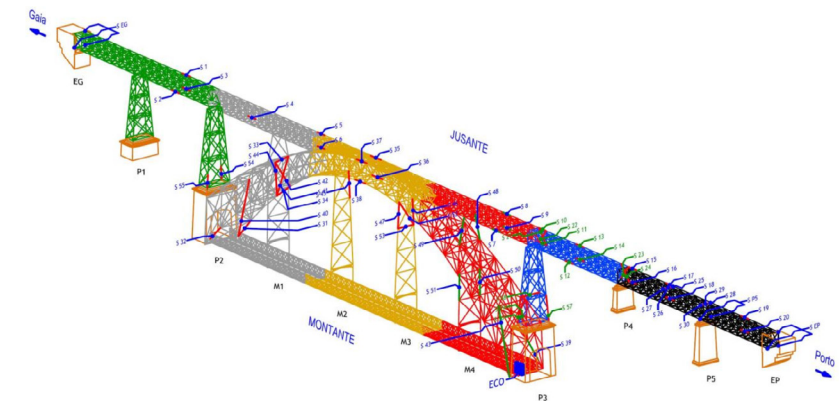
Monitoring system of the Luiz I Bridge.
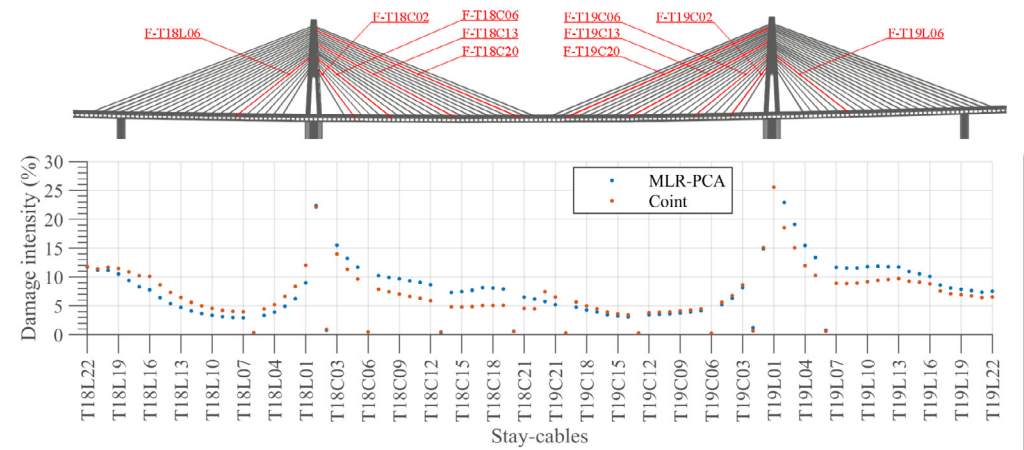
Minimum detectable damage in each of the 88 stay-cables of the Corgo Bridge using the data collected on the 10 instrumented cables (identified in red). Two algorithms were tested: Multilinear Regression & Principal Component Analysis (MLR-PCA) and Cointegration (Coint). Damage intensity expressed as the cross-sectional area reduction.

DESDEMONA — DEtection of Steel DEfects by Enhanced MONitoring and Automated procedure for self-inspection and maintenance

Principal Investigator
Álvaro Cunha

Total funding
210 117€

Source of funding
European Commission

DESDEMONA objective is the development of novel design methods, systems, procedure and technical solution, to integrate sensing and automation technologies for the purpose of self-inspection and self-monitoring of steel structures. The approach will lead to an increment of the service life of existing and new steel civil and industrial infrastructure and to a decrease in the cost associated to inspections, improving human activities performed in difficult conditions, safety and workers; potential by the use of advanced tools. The research aims to expand beyond the current state-of-the-art new high-quality standard and practices for steel structure inspection and maintenance through the interrelated development of the following actions: i) steel structure geometry and condition virtualization through data fusion of image processing, thermography and vibration measurements; ii) developing of procedure for steel defect detection by robotic and automatic systems such as Unmanned Aerial Vehicles (UAV) and ground mobile robots iii) embedding sensor systems to revalorize and transform steel elements and structures into self-diagnostic (smart) elements and materials even through nanotechnologies, iv) realizing an experimental lab-based apparatus and a series of case studies inspected by intelligent and robotic systems. The project outcome will have an impact on the reduction of the cost of steel structures inspection and maintenance and on the increase of user safety and comfort in industrial and civil environment. The proposal with a multidisciplinary approach fulfils the objectives of the Strategic Research Agenda of the European Steel Technology Platform.
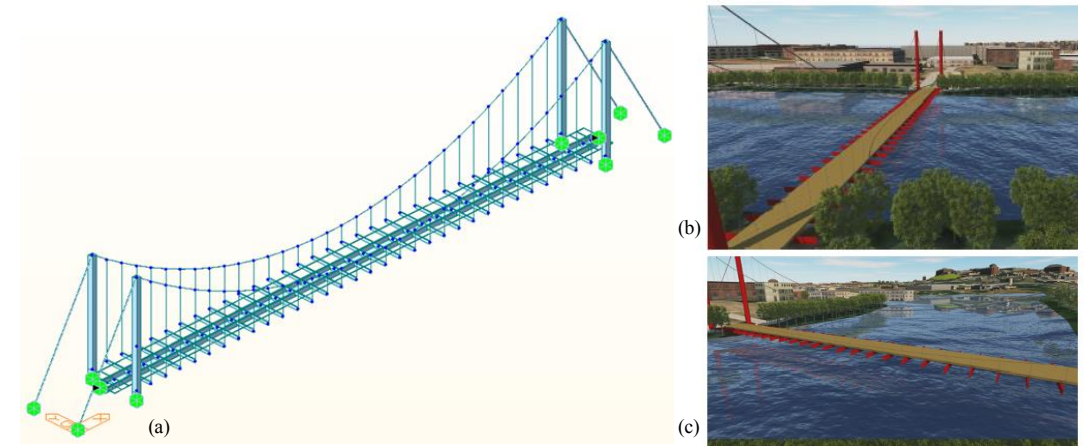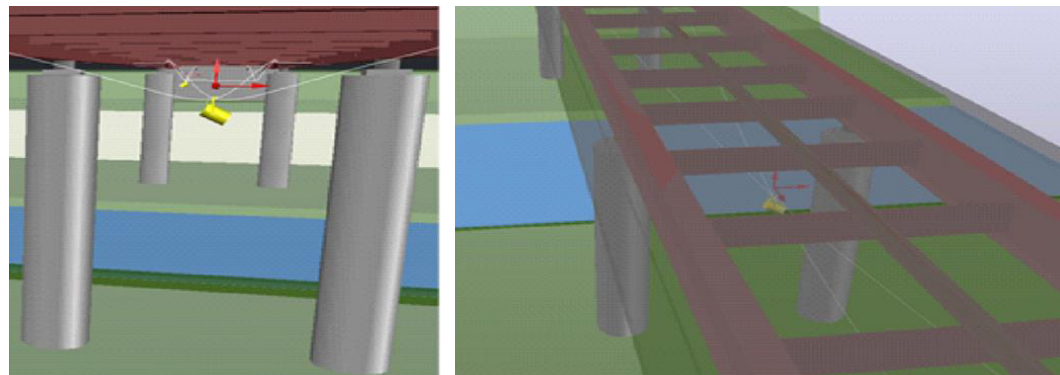
SAFESUSPENSE — Safety control and management of long span suspension bridges

Principal Investigator
Elsa Caetano

Total funding
120 209€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

Long span suspension bridges (LSSB), the construction of which started in the 1960s in Europe, represent infrastructures of great social and economic importance for communities, both at regional and national levels. The ageing of these structures, in many instances with deterioration effects occurring at earlier than predicted moments, the adapting of their functionalities to non-expected volumes of traffic, and the society?s requirements for safer, securer, and more efficient and sustainable mobility, have motivated an increased demand for investment in maintenance, modernization and retrofit. Making use of the developments in instrumentation, computation power, data storage and communication, it has become possible, in the last few decades, to implement monitoring programs in LSSB with the purpose of assessing their condition. This project aligns in this trend and aims at going one step further, in filling the gap between data and automatically extracted structural parameters, and the actual information regarding the structural condition that can be used by bridge owners. It will focus on an existing LSSB where an extensive monitoring program has already been implemented, comprehending more than 200 sensors. By establishing a database of potential damage scenarios with different levels of importance, using complementary numerical simulations, and developing and implementing new artificial intelligence and pattern recognition algorithms,

it will be possible to detect and identify damage in real time. This is particularly relevant for components as the main cables, which are highly non-redundant, and for the thousands of metallic elements prone to corrosion and fatigue, and sensitive to traffic accidents, the integrity of which is still largely assessed using visual inspection. The major original developments to be made in the project, which are also the milestones to be reached, consist of supporting LSSB management by achieving (i) high sensitivity to damage, (ii) real-time capability and (iii) absence of false alerts. To achieve the proposed objectives, the project team is formed by researchers from the Faculty of Engineering of Porto (FEUP) and the National Laboratory of Civil Engineering (LNEC). The two entities have a long tradition of cooperation and the researchers involved have complementary competences. Researchers from FEUP have strong background in dynamics of cable structures, vibration-based monitoring and detection of damage. Researchers from LNEC, who are already responsible for the monitoring program in an LSSB, have an extensive background in structural monitoring, artificial intelligence and pattern recognition algorithms as well as life-cycle management. An international consultant with strong background in the area will help the team with the achievement of the proposed goals. Support and interaction with the LSSB owner is expressed by the submitted comfort letter.
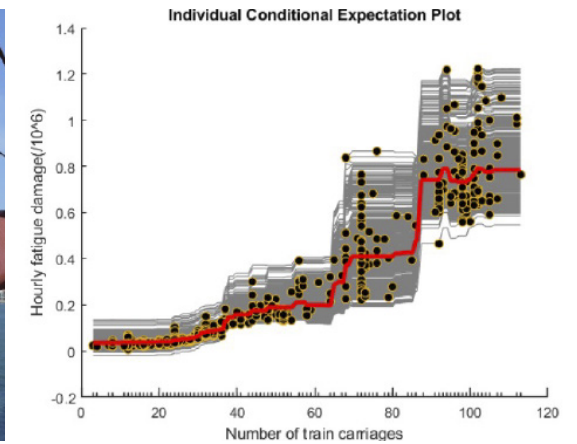
CTWAVE — Identification of cable damage from transverse wave propagation

Principal Investigator
Elsa Caetano

Total funding
49 944 €

Source of funding
FCT - Fundação para a Ciência e Tecnologia
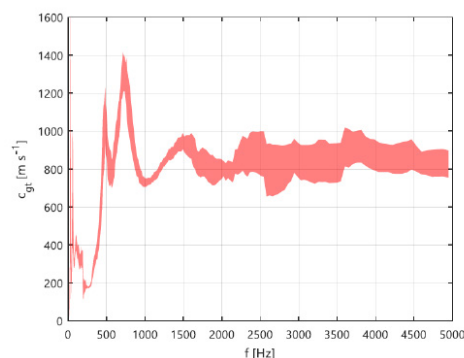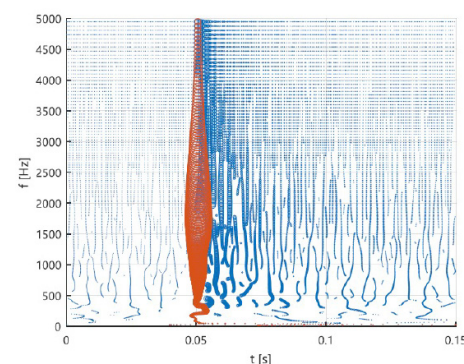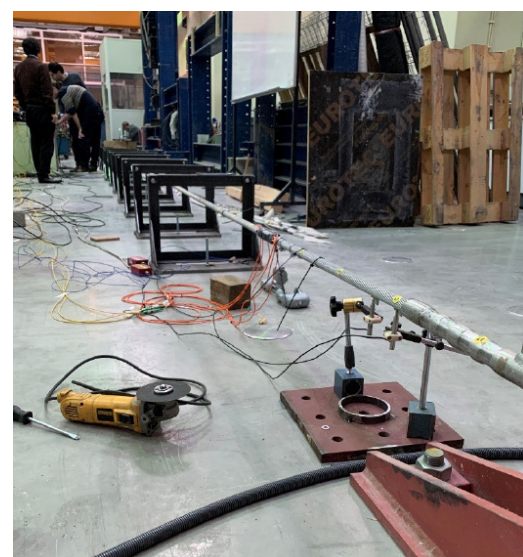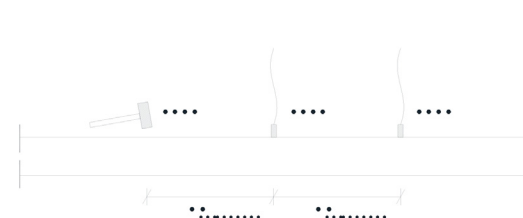
During the last few decades, vibration-based techniques have become widely used in the assessment of the force installed in cables. While the original application of the so-called vibrating chord theory to the identification of the tensile force was verified as accurate for high and relatively long cables {1}, the need to inspect cables with other characteristics (low tension, short or uncertain length) has led to extend such methods beyond their limit of application.

To improve the quality of force estimation, different authors proposed the implementation of different regression or optimization techniques {2,3,4}, which may lead to improved estimates of the free cable length, the moment of inertia of the cross-section and the force.

However, these methods still rely on the knowledge of the end conditions of the cable, not to mention that the ill-conditioned nature of the optimization method, with very different sensitivities of the various involved parameters, may result in the estimation of sets of parameters that are local minima and not the real solutions of the problem.

The present project aims at developing and validating experimentally a new method for the identification of cable force and mechanical properties of a tensioned cable. This method is based on the direct measurement of the velocity of propagation of transverse waves and employs dispersion relations to deduce the mechanical properties, namely the bending stiffness and the shear coefficient of the cross-section. In parallel, the use of this propagating velocity in the vibrating chord formula enables the estimation of the cable force without the need of specifying boundary conditions. This is particularly interesting in cables of cable-stayed bridges where dampers are employed, changing the cable mode shapes, or else when short cables need to be assessed where the uncertainty in the definition of the length would result in low accuracy of the estimated force. In combining a local measurement of the velocity of propagation of waves with the measurement of global cable frequencies, the method enables the identification of damage along a cable, as a result of the variation of the corresponding mechanical properties. The project comprehends the systematization of the already developed formulation and sensitivity test studies to identify ranges of

parameters and confidence intervals of the estimates, in particular related to the percentage of damage that is identifiable. In the second stage, a laboratory validation will be accomplished by the test of different types of cables at different levels of tension, with different levels of degradation. Prototype tests will complement the laboratory tests and will be used as proof of concept.

The project team is composed of highly experienced researchers in cable dynamics {5}, dynamic testing {6}, damage assessment {7} and site experience with cable bridges and special structures {8, 9}. In particular, the PI obtained a PhD in Cable Dynamics and has done research on the topic for the last 20 years, being involved at consultancy level in numerous studies related to the characterization of cable force, as the suspended roof for the London Olympic Stadium in 2012 {10}. In the present proposal, she is responsible for the formulation regarding the identification of force and damage as a function of the velocity of transverse generated waves, which is being developed together with João Rodrigues in the context of his PhD research. The PI and all the members of the team have a wide experimental background which will be necessary both for the laboratory validation and the prototype tests. The co-PI has a PhD in Dynamics and Control of Vibrations and has been highly active in the development of sensors and setups for dynamics tests of different nature. In this project, he will be fundamental in the development of laboratory test setups.

The proposed method constitutes an entirely new approach by comparison with other existing vibration-based assessment methods, with the great advantage of the easiness of application and expected high accuracy due to the non-required knowledge of the cable length in the assessment of cable force and properties. At the international level, the validation and demonstration of the proposed method may constitute an important step in both the assessment of cable force and damage, contributing to improve the safety and eventually extend the lifetime of important infrastructures that presently exist throughout Europe and are reaching their end of life. It is further expected that, in the future, this method will be implemented automatically by means of a robot that will run along a suspension cable, for example, to locally detect damage.

SMART_OPS — Smart Monitoring System for large equipment for bridge construction

Principal Investigator
Filipe Magalhães

Total funding
186 225€

Source of funding
Agência Nacional de Inovação S.A.

SMART_OPS aims to research and develop a smart monitoring solution for large equipment used in bridge construction, which has a low level of instrumentation, high operating costs, low productivity and inefficiencies in the process. Therefore, the project will create a new R&D area on BERD, performing the diversification of its proposal for advanced systems in smart monitoring of large equipment for the construction of bridges. The main goals of the project are to obtain a data acquisition system; data analysis and processing algorithms; instrumentation component of the equipment; different techniques of data mining, a real-time information system and data storage, and a user interaction interface that allows monitoring and making decisions at different stages of the bridge construction process. Therefore, the project intends to respond to several technical limitations of the technology and the challenges imposed by the digital transformation of the construction sector, since it proposes to develop an innovative solution of monitoring equipment used in the construction of bridges. It proposes an advanced solution that will use the implementation of smart sensor networks, data collection and storage, cyber-physical systems and Human-to-Machine interfaces (HMI). Which are precursors of Industry 4.0. The project is structured in a total of 6 activities, with industrial research activities: preliminary studies, technical requirements specifications of monitoring system and instrumentation, technological development of the specified solutions; as well as experimental development activities: validation and testing of the prototype of the monitoring and instrumentation solution for the large equipment; promotion and dissemination of results; and, finally, the management and coordination of the project. The consortium is defined by two co-sponsors, BERD and University of Porto, by the Faculty of Engineering of the University of Porto (FEUP), more specifically the R&D unit named CONSTRUCT. BERD and FEUP intend to strengthen the relationship between the entities to implement the project activity plan.
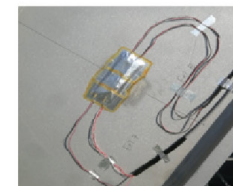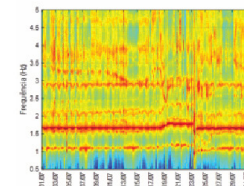
IN2TRACK2 — Research into enhanced track and switch and crossing system 2

Principal Investigator
Rui Calçada

Total funding
559 277€

Source of funding
European Commission

The IN2TRACK2 proposal addresses the topic of Research into optimised and future railway infrastructure; of the 2018 HORIZON 2020 SHIFT2RAIL Call for proposals for the Joint Undertaking Members (S2R-CFM-IP3-01-2018). IN2TRACK2 deals with rail infrastructure subsystem and covers all the works on Switch & Crossing (S&C), Track and Structures (Bridges and Tunnels) included in the SHIFT2RAIL Innovation Programme 3 (including the project IN2TRACK) and contributes to the full longer-term SHIFT2RAIL objectives. IN2TRACK2 represents the opportunity to choose some high-risk, innovative activities from the current SHIFT2RAIL work programme for development under intensive collaboration as the right path for success. IN2TRACK2 aims to reduce lifecycle costs, improve reliability and punctuality, whilst increasing capacity, enhancing interoperability and improving the customer experience. The structure of the work plan is designed around the development of a certain number of well-focused technological innovations in several areas (S&C, Track and Structures), each and all together, will contribute to achieve the desired impact at the overall railway system level. The IN2TRACK2 proposal is organised around three technical sub-projects, which are interconnected: S&C, Track and Structures. S&C activities aim at both improving the operational performance of existing S&C and providing radical new S&C system solutions that deliver a step-change in performance of the asset. The IN2TRACK2 Track activities aim at both exploring new track construction to optimise the today track system and improving the track system substantially to provide a step change in performance. The IN2TRACK 2 Bridges and Tunnels activities aim at improving methods and repair techniques to reduce costs, improve quality and extend the service life of structures. By enhancing S&C, Track and Structures, IN2TRACK2 contributes to all of the expected impacts identified in the Shift2Rail Annual Work Plan 2018.

IN2TRACK3

Principal Investigator
Rui Calçada

Total funding
571 601€

Source of funding
European Commission

The European railway industry faces great challenges in need for increased network capacity. Ageing infrastructure assets require efficient and sustainable interventions to maintain and improve current levels of performance. To meet these demands and increase the operational performance of the railway infrastructure assets, innovation is needed to enable a step-change in reliability, availability, maintainability and safety (RAMS) and also to optimise asset capital and LCC. The IN2TRACK3 proposal addresses the topic of Research into optimised and future railway Infrastructure of the 2020 Horizon 2020 SHIFT2RIL call. The project is a continuation of IN2TRACK and IN2TRACK2 and aims to further develop and demonstrate research results and innovations developed. IN2TRACK3 will develop physical as well as digital technology and methodology demonstrators for the Track, Switches & Crossings and Bridge & Tunnel assets and the project is aligned to the SHIFT2RAIL overall aims. The project structure is designed around three technical sub-projects aiming at both improving the operational performance of existing infrastructure assets and providing radical new system solutions delivering a step-change in performance, improving methods and repair techniques, improve quality, reduce costs and extend the service life of assets and structures. The project is led by Trafikverket, the Swedish Transport Administration Agency, the consortium consists of 27 expert partners originating from 11 European countries and the partners involved are infrastructure managers, research partners, technology developers and industry partners. IN2TRACK3 will further develop and demonstrate a number of innovative solutions based upon the two previous projects and the work will build upon already ongoing mutually beneficial collaboration, established communication paths and a considerable amount of mutual trust built upon years of collaboration in international project environments.
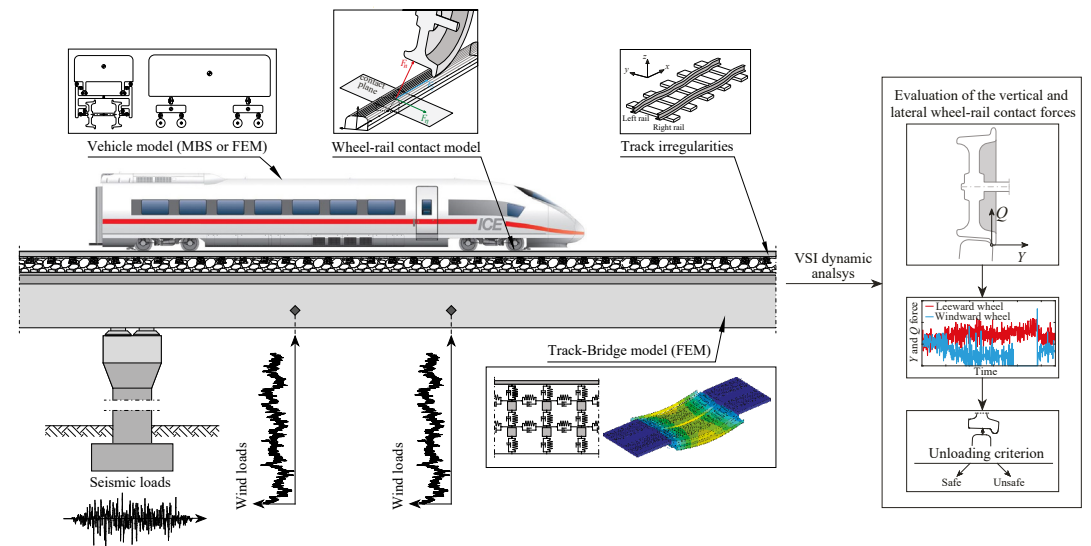
IN2RAIL — Innovative Intelligent Rail

Principal Investigator
Rui Calçada

Total funding
60 063€

Source of funding
European Commission

IN2RAIL is to set the foundations for a resilient, consistent, cost-efficient, high capacity European network by delivering important building blocks that unlock the innovation potential that exists in SHIFT2RAIL: innovative technologies will be explored and resulting concepts embedded in a systems framework where infrastructure, information anagement, maintenance techniques, energy, and engineering are integrated, optimised, shared and exploited. IN2RAIL will make advances towards SHIFT2RAIL objectives: enhancing the existing capacity fulfilling user demand; increasing the reliability delivering better and consistent quality of service; reducing the LCC increasing competitiveness of the EU rail system. To achieve the above, a holistic approach covering Smart Infrastructures, Intelligent Mobility Management (I2M)and Rail Power Supply and Energy Management will be applied. Smart Infrastructure addresses the fundamental design of critical assets - switches and crossings and tracks. It will research components capable of meeting future railway demands and will utilise modern technologies in the process. Risk and condition-based LEAN approaches to optimise RAMS and LCC in asset maintenance activities will be created to tackle the root causes of degradation. I2M researches automated, interoperable and inter-connected advanced traffic management systems; scalable and upgradable systems, utilising standardised products and interfaces, enabling easy migration from legacy systems; the wealth of data and information on assets and traffic status; information management systems adding the capability of nowcasting and forecasting of critical asset statuses. Rail Power Supply and Energy Management create solutions to improve the energy performance of the railway system. Research on new power systems characterised by reduced losses and capable of balancing energy demands, along with innovative energy management systems enabling accurate and precise estimates of energy flows.
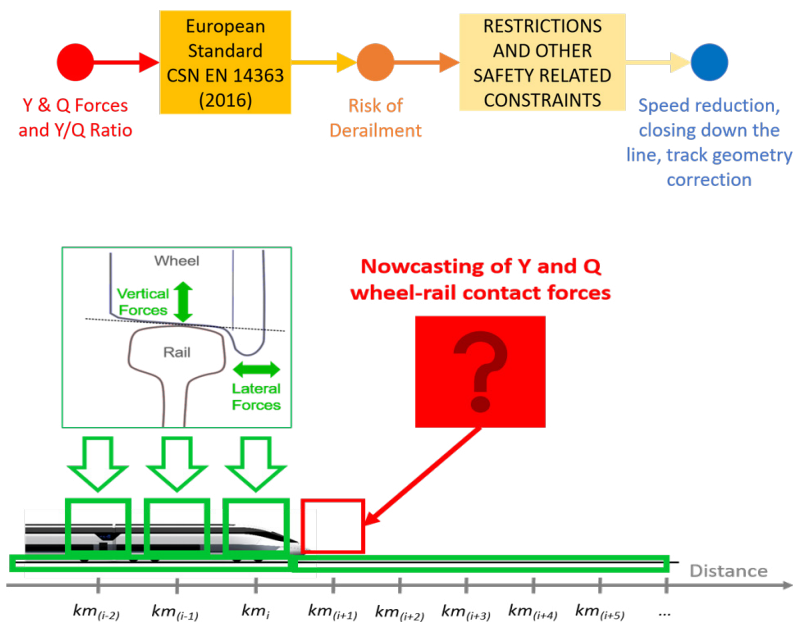
RISEN — Rail Infrastructure Systems Engineering NetworkInnovative Intelligent Rail

Principal Investigator
Rui Calçada

Total funding
180 000€

Source of funding
European Commission

HE4u2 will contribute to the reform of teaching and learning in higher education and the improvement of the retention and attainment of migrants and ethnic minority students. There is a clear need and demand for training of teachers in relation to migrant students, for reform in the delivery of support for these learners, and in the intercultural dimension for all learners. HE4u2 will develop an integrated pedagogical approach to the intercultural dimension of existing curricula, CPD courses for staff, and policy recommendations. HE4u2 will focus on the curricula and the teachers of adults in HE: they often provide access for disadvantaged groups, are student centered, have specialised support, and links to regional agencies. There is a concentration of expertise, a capacity to respond effectively to new needs, familiarity with employers, and experience in staff development; there are internal and national networks (all members of eucen) for mainstreaming innovation and influencing policy. The project will: -Produce a meta-analysis of best practice from relevant research and tools across Europe and survey current learners from diverse backgrounds to obtain their views on the most important features of the curriculum. -Design, test and finalise innovative pedagogy in 3 different curricula in each of the 7 partner HEIs/countries and elaborate guidelines for developing such curricula by HE teachers and other relevant staff in 3 languages EN, FR and DE. -Design, test and finalise CPD courses incorporating ECTS, for HE teachers, adaptable to other settings. -Produce an analysis of the policy process and a policy paper with recommendations for HEIs, national and European agencies. At each stage, the partners will work with policy actors at national level and eucen will do this at European level; in-depth transnational consultations will maximise the impact of the project on the national systems of HE and on the European policy agenda.

FiberBridge — Vibrations induced by railway traffic in tunnels: an integrated approach

FiberBridge is focused on the fatigue strengthening and assessment of railway metallic bridges using fiber-reinforced polymers. This is very important for Portugal, and indeed in Europe. The European Union is committed to making the transport of goods and the mobility of people more secure, efficient and environmentally friendly, with priority being given to social and territorial cohesion, as well as to economic dynamism. The FiberBridge project is aligned with the promotion of a resource efficiency economy, with the use of new materials to further reinforce the safety of the metallic bridges of railway infrastructures in Portugal. Due to economic factors, railway metallic bridges have had their operating time extended. This makes it necessary to carry out detailed studies of residual life to fatigue to substantiate the decisions to extend the operational period of these bridges. A global dynamic analysis and fatigue assessment of the case-studies (e.g. Eiffel bridge) has the aim to develop a numerical model and experimental study. A finite element model of the selected bridges is calibrated using measured responses for ambient vibration test, which will be provided at an early stage of the project by the research team. The fatigue damage will be initially evaluated without reinforcement solutions. The monotonic and fatigue behaviour of tructural adhesives will be further analysed through an experimental activity. Fatigue experimental and numerical model studies will be carried out for a range of notched steel specimens using the FRP plates. Fatigue behaviour results of adhesives are important for use in advanced numerical models of fatigue strength prediction for resin-injected bolted and hybrid steel-FRP?s connections. The study of different configurations of notched steel details reinforced with FRP plates are important for estimating the gain of fatigue resistance of bridge structures. For the fatigue life predictions considering the fatigue crack propagation phase of these structures, it is also important to assess the crack growth behaviour and characterization of fiber-reinforced pre-cracked specimens. Fatigue strengthening experimental and numerical model studies of old metallic bridges members with FRP plates will be conducted. The fatigue rehabilitation is usually expected to decrease the stress concentration at the critical point and the stress intensity at the tip of the crack. Finally, the fatigue damage structural resistance evaluation of selected case-studies with reinforcement solutions using a global-local experimental-numerical methodology will be performed, taking into account the previous analysis. TheFiberBridge expected results iclude the identification of positive contributions in the dynamic analysis and fatigue life prediction of the FRP plates application in critical details of the railway metallic bridges, as well as the development of important procedures/guides for the design codes.

iPBRAIL — Innovative Precast Bridges for RAILways

Principal Investigator
Rui Calçada
Mário Pimentel (from 27/10/2022)

Total funding
486 802€

Source of funding
Agência Nacional de Inovação S.A.

Presently, the prefabrication industry does not exploit the potentialities offered by materials of the types HPFRC and UHPFRC. This Project aims at conceiving new products for railway bridge decks, taking full benefit of the potentialities offered by these materials. HPFRC will be used to conceive and develop precast pretensioned girders without ordinary reinforcement in the general area of the girder and coupling beams in the modular system of the bent-type frame. UHPFRC will be used to conceive innovative connection solutions between precast elements, thus obtaining proper structural behaviour and high durability without continuity post-tensioning applied in-situ. Small and medium span structures (up to 30m) are envisaged in this Project. Besides that, a system of precast planks (effective in service) will be developed for railway bridge decks, suitable for the new girders, as well as segmented columns and their continuity connections. In order to reach these objectives, the Project comprehends tasks devoted to conceptual design, computational analyses, safety verifications considering all the relevant limit states and laboratorial works. The laboratorial tasks will allow defining the material compositions, characterizing the material properties, validating the structural performance of the new products and supporting the development of design criteria. The Project team gathers all the required competencies to reach the Project objectives. The leader (Mota-Engil Engenharia e Construção, MEEC) has a vast experience in construction and rehabilitation of railway structures and in concrete prefabrication. The second partner (Faculdade de Engenharia da Universidade do Porto, FEUP) gathers scientific and technical competencies in all the Project domains, as well as laboratorial infrastructures which are essential for the Project development.

FERROVIA 4.0

Principal Investigator
Rui Calçada

Total funding
960 800€

Source of funding
Agência Nacional de Inovação S.A.

The FERROVIA 4.0 project aims to address the technological and market challenges of the railway sector around the world, stimulating a mobilizing collective action around a wide range of companies and entities of the R&I System that integrate the Portuguese Railway Platform Group, conducting industrial research activities that foster the experimental and statement of the development new data technologies with greater operational capacity, sustainability and competitiveness of railway systems. The project aims to upgrade its different components, tools and systems to being tested in circulating material and real infrastructures, that are geared towards the sustainability of the railway system, the reduction of operating and maintenance costs; for reliable asset management decision support information systems and the creation of alert systems to trigger protection / intervention measures. It is also an objective of the Project to ensure that the cybersecurity technologies and methodologies are incorporated in the technologies structures of information and communication of the railway system, in order to avoid unwanted intrusions To achieve its objectives, the FERROVIA 4.0 project introduces 4 PPS (Products, Processes, Services) with R&D activities, to which is added a PPS of Management and Wide Dissemination of the Results, that will be executed by 22 entrepreneurial entities and non-entrepreneurial entities and 4 renown partners of the Railway sector in Portugal, bringing together the most diverse skills and enhancing a consolidation of the Portuguese offer of solutions for the railway systems.

Localização dos sistemas de aquisição

Instrumentação da plataforma do vagão

Plataforma
- 3 acelerómetros MEMS DC (± 50g) na direção transversal
- 3 acelerómetros MEMS DC (± 50g) na direção vertical
- 2 GPS
- 1 inclinómetro

Instrumentação das caixas de eixo e suspensões

	Eixo Frontal	Eixo Traseiro
Lado Esquerdo		
Lado Direito		

Eixos
- 1 acelerómetro MEMS DC (±200 g) triaxial
- 2 acelerómetros (±500 g) na direção vertical
- 1 acelerómetro MEMS DC (±200 g) na direção vertical
- 1 acelerómetro MEMS DC (±200 g) na direção transversal

iNBRAIL — Innovative Noise Barriers for Railways

Rail transport systems are the most sustainable transport mode, with the lowest energy consumption, space occupation and carbon footprint when compared to any other air or land transportation systems. However, the noise generated by railways constitutes a very significant environmental challenge that the managers and operators of this type of infrastructure need to face. Among mitigation measures that can be followed, the implementation of acoustic barriers is the most common and one that presents the greatest impact on noise reduction. In spite of this, the acoustic barriers usually applied are far from being optimized solutions and are not generally designed for the specific case of railway noise. In this context, the main objective of the project is to develop of an innovative acoustic barrier solution, specifically designed to minimizing noise effects elicited by railway traffic. It is intended that the solutions to be developed can constitute efficient barriers from an acoustic point of view and with a low environmental / visual impact, corresponding to solutions of low height and with optimized geometry. From the economic point of view, advantage will be taken from the modular nature of concrete pre-cast solutions. The main goal is that this type of solution is highly competitive in relationship to existing solutions in the market, in terms of technical, economic, sustainability and visual impact. The development of the project will be based on a consortium established between three entities highly qualified for this purpose, relying on the extensive experience accumulated in the concrete pre-cast industry by Mota-Engil, and the experience and scientific knowledge regarding the acoustic performance of different mitigation solutions of the UC, and the global behavior of railway systems at the UP. The project is also supported by two railway manager administrations (as partners), namely Metro do Porto and Infraestruturas de Portugal.
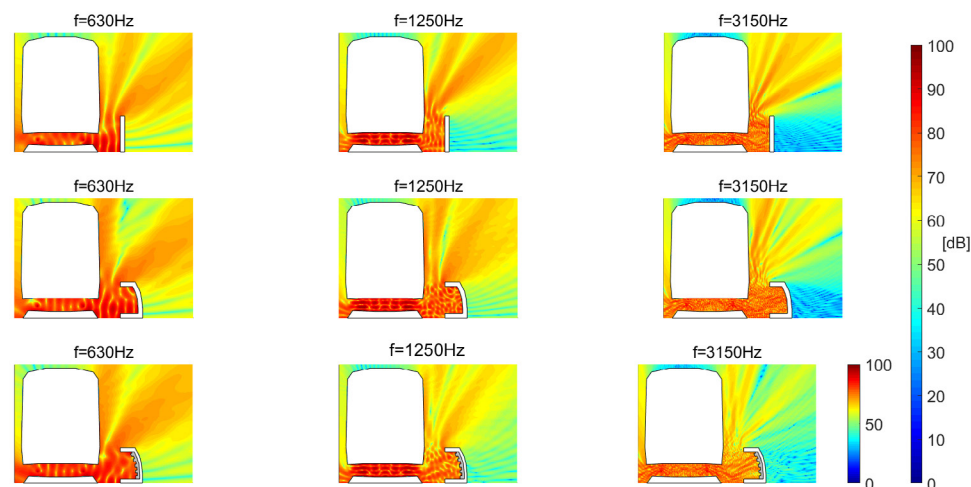
Way4SafeRail — WAYside monitoring system FOR SAFE RAIL transportation

Principal Investigator
Rui Calçada

Total funding
370 333€

Source of funding
Agência Nacional de Inovação S.A.

The rail sector has been playing an increasingly important role in society, and safety in traffic and maintenance costs are important aspects for railway managers and operators. Monitoring systems aim to contribute to these two aspects: safety and optimization of maintenance actions. However, current monitoring systems placed on the railway, despite identifying geometric defects in the wheels, such as flats, do not categorize them in terms of severity or identify in operation, risk situations in railway circulation, such as unbalanced loads and loop movements. In this context, the WAY4SafeRail project aims to design a low-cost monitoring system capable of: (i) assessing the condition of the train wheels in operation, monitoring and categorizing their severity; (ii) detecting situations of instability in railway circulation, such as unbalanced loads and loop movement; iii) identifying events occur-

ring in infrastructure not related to the passage of trains that may have an impact on the safety of movement. It is intended that the monitoring system can be applicable to various data acquisition and instrumentation equipment?s installed in railway infrastructures. As such, the main focus of Research will be on the design of tools for the acquisition, processing and communication of data obtained and on the use of analytical techniques and artificial intelligence to identify the deviation from the expected condition. The project will be structured around 6activities: A1 - Project management; A2 -Requirements and Specifications; A3- Monitoring System; A4 Knowledge Extraction; A5 - Integration, Tests and Demonstration; A6 - Promotion and Dissemination of results. It is expected, at the end of the project, to demonstrate and validate the results of the project regarding the use cases to be specified.

NVTrail — Vibrations induced by railway traffic in tunnels: an integrated approach

Principal Investigator
Pedro Costa

Total funding
179 651€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The transport system is one of the strategic factors for the sustainable development of modern cities, where environmental requirements play a key role. The main purpose of the present project is to create tools to predict vibrations and re-radiated noise in buildings due to railway traffic in tunnels. These models would then be applied and acted upon the end-user, creating a considerable added value for the development of more sustainable urban environments. The research proposal takes handle of a comprehensive approach (analytical, numerical and experimental) to construct tools for the prediction and mitigation of vibrations and re-radiated noise induced by railway traffic in tunnels. The knowledge developed in topic, combined with an appropriate dissemination, will provide the technical communities and decision makers with tools for the reduction of pernicious environmental impacts, allowing improving the well-being of the communities living surrounding railway infrastructures.

META_SHIELD — Vibration shielding periodic metamaterials

Principal Investigator
Pedro Costa

Total funding
65 220€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The proposed project involves the definition of new concepts for vibration shielding devices, which may correspond to a change of paradigm when compared to existing strategies. The main objective is to contribute to the definition of new technological solutions that can help giving response to a very relevant worldwide societal challenge, which is the mitigation of the vibration effects in the human being and built environment. It is our goal to contribute to the definition of new and efficient shielding measures that help to:

· Improve the comfort of building users, by minimizing the vibration levels to which they are exposed;
· Reduce the vibration levels near historical buildings, which require protection to vibrations in order to minimize their degradation;
· Protect existing sensible buildings, which, due to their usage or specificities, cannot be exposed to higher levels of vibration.
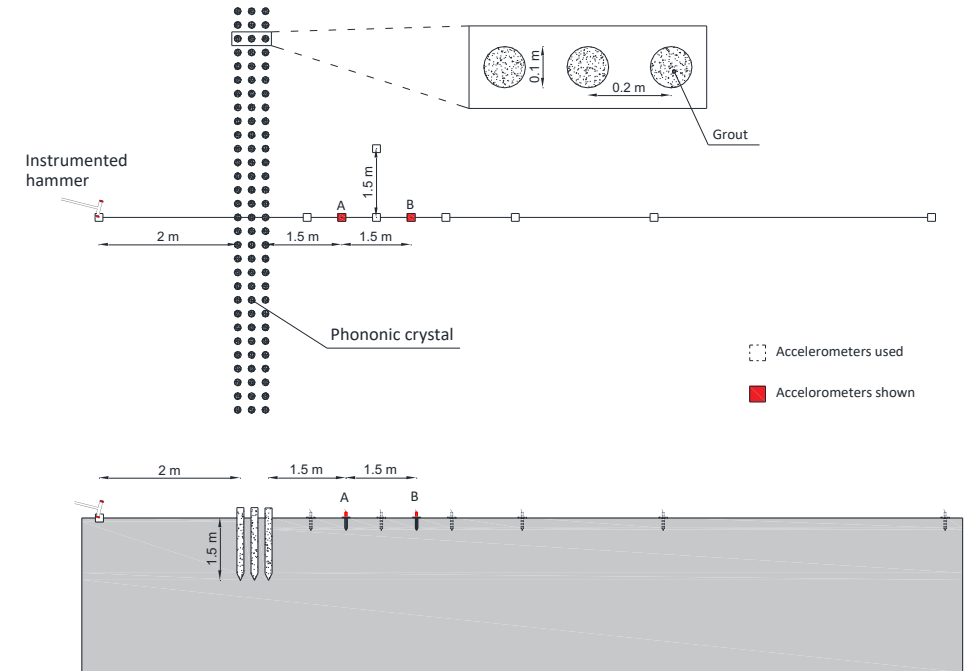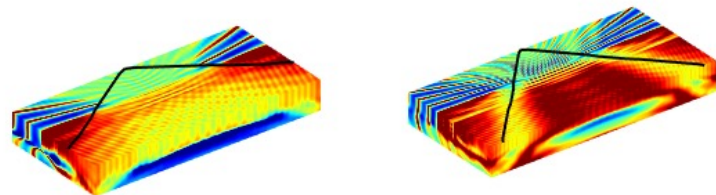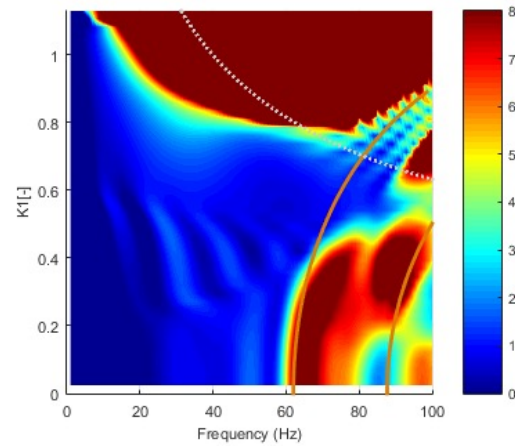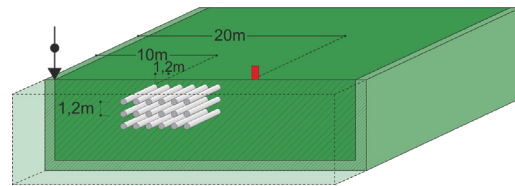
InBridge4EU — Enhanced Interfaces and train categories FOR dynamic compatibility assessment of European railway BRIDGEs

Project coordinator
University of Porto / FEUP

Funding FEUP
142 513,89 €

Duration
01/09/23 – 31/08/26 (36 months)

Principal Investigator
Pedro Montenegro

Total funding
928 114,51 €

Source of funding
European Commission

The shift to more sustainable mobility systems is one of the major priorities to accomplish the goals established by the European Green Deal to make Europe the first climate neutral continent by 2050. Railways plays a crucial role in this regard, but it is essential to enhance the current resilience and capacity of the network, in particular from lifeline structures, such as bridges. Within this regard, several open points affecting the current INF TSI and described in the ERA Technical Note are yet to be closed, namely those related to the Dynamic Train Categories previously specified in EN15228:2015 and the limits of validity of the static compatibility checks currently stipulated EN15228:2021, the accuracy of the current dynamic amplification factors and damping values for railway bridges proposed in EN1991 2 (2003) and the validity of the deck acceleration limits imposed by EN1990-Annex A2 (2005) in both new and existing bridges.

InBridge4EU aims to answer these points through the formulation of an enhanced and harmonized method to assess the European dynamic interface between railway bridges and rolling stock. The outcomes of this project will provide solid background to the guidance being drafted within the CEN/TC250/SC1 special group DIBRST for dynamics of bridges. Finally, as a consequence, the economic outcomes of changing any of the aforementioned criteria/parameters /methodologies in the current European railway bridge landscape will be carefully assessed. All the research carried out in InBridge4EU will converge on recommendations to ERA and CEN for revising and updating the current version of the TSIs and Eurocodes. Advanced numerical modelling and dynamic analyses of both bridge and railway vehicles, together with the development of extensive databases of bridge and rolling stock data obtained from the different partners of the consortium, will contribute to the successful achievement of the project's objectives.
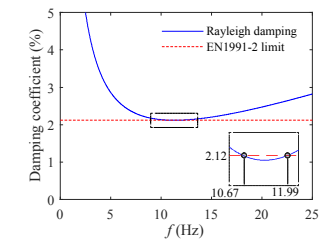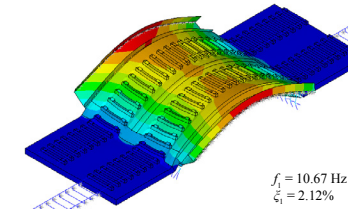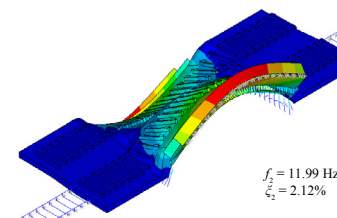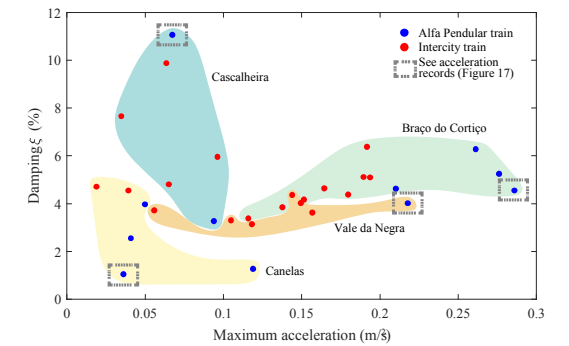
SMART WAGONS — Development of production capacity in Portugal of smart wagons for freight

Project coordinator
Medway - Maintenance & Repair, S.A

Principal Investigator
Rui Calçada (until 26/10/2022)
Pedro Montenegro (from 27/10/2022)

Funding FEUP
2 026 674,07 €

Total funding
64 219 200,04 €

Duration
01/07/22 – 30/06/25 (36 months)

Source of funding
IAPMEI, I.P. / PRR

As rail transport plays a very relevant role in achieving the objectives outlined in the European Green Deal, namely in promoting environmentally friendly modes of transport and achieving carbon neutrality by 2050, it is essential to continue to invest in the capacity building and development of the European and national railway sector. The use of this means of transport is still low, with only 11% of goods being transported through the railway network.

Obsolete infrastructures, outdated business models and high maintenance costs are some of the obstacles identified by the EU and which must be overcome in order to build a unified European railway area. Around 1.5 billion tonne-kilometres of goods are currently transported in Europe by truck over distances of more than 150 km, as opposed to the 0.4 billion tonne-kilometres (20%) transported by train, which entails very significant environmental costs. A significant part of road freight transport should be shifted to rail. For this to happen, it will be fundamental that freight trains lower their costs and significantly improve the quality of the current wagon fleet. Thus, quality standards such as reliability, flexibility, availability, cargo safety and protection, punctuality, customisation, marketing, traceability, complementary services and transport time, among others, will have to be improved by rail operators.

The existing solutions in the market for rail transport of goods are, in most cases, solutions that are already several decades old, with a low level of incorporation of knowledge and new technologies. Thus, the possibility of national production of a differentiated product for freight transport, with high technology incorporation, rethinking the materials and respective manufacturing processes, aiming at its greater sustainability, embodies the disruptive idea of the SMART WAGONS Project. This initiative, structuring for the Portuguese economy, aims to promote and recapture Portugal's manufacturing capabilities of intermodal wagons with incorporated onboard sensoring systems to enhance their safety and efficiency through the implementation of predictive maintenance procedures.
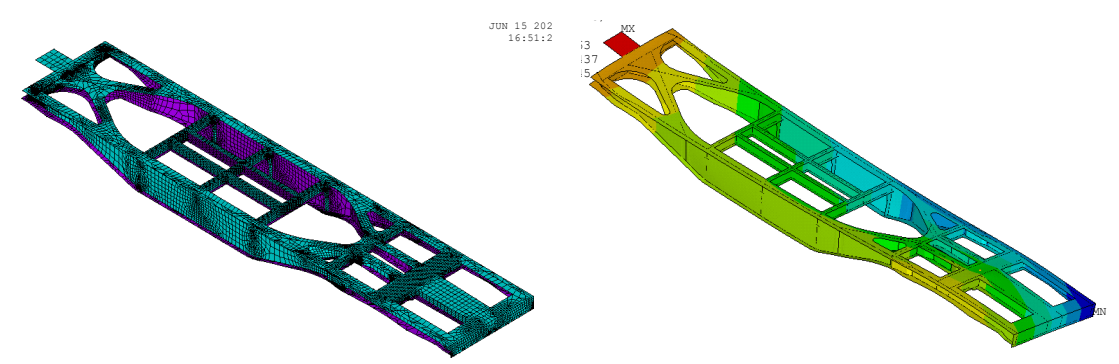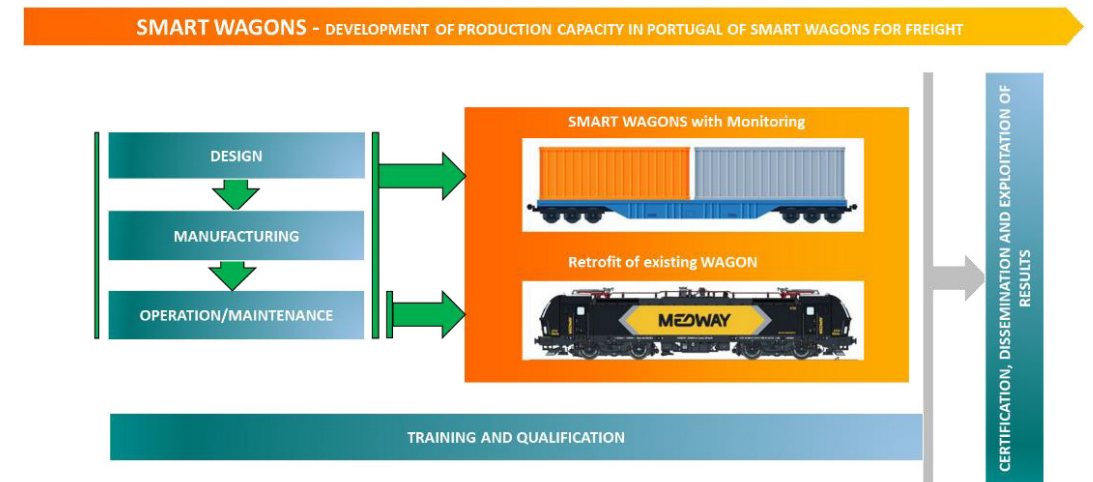
Producing railway rolling stock in Portugal

Project coordinator
Sermec II - Indústria, Comércio e Serviços, S.A.

Principal Investigator
Rui Calçada (until 31/05/2022)
Abílio de Jesus (from 01/06/2022)

Funding FEUP
3 981 470,79 €

Total funding
57 985 576,57 €

Duration
01/01/22 – 31/12/25 (48 months)

Source of funding
IAPMEI, I.P. / PRR

The project seeks to bring together the most relevant entities, in an integrated logic, capable of developing a project with a strong strand of innovation and development combined with productive investment, seeking to realize the production of a new product – the manufacture of railway rolling stock, embodied in a typology of three carriages, promoting technologically advanced production by companies. The proposal presented here has as its main objective to contribute to the diversification and complexification of the productive structure and the specialization profile of the Portuguese economy (both in its core industrial area, which corresponds to the metalworking/rail sector, or in other industrial areas associated with companies that will necessarily be called to perform important complementary functions for a good implementation of the project). But it is also at the service of an interest that is combined and related to the reanimation of the railway in Portugal and the use of historically installed but largely unused skills in the context of the public company that is central in this area, the CP; also responding, even if only partially, to specific problems by this sense, especially for reasons of scarcity of financial resources, in the context of increasing and modifying its supply to respond to a growing demand and the demanding challenges and commitments that are being on the agenda. The prototype, when finalized and homologated, will be placed in CP's commercial operation leveraging the quality of public service as well as opening opportunities for the construction of rolling stock in Portugal with Portuguese companies as well as the possibility of a faster response to CP's needs. The conceptual idea of this project is to participate, by horizontal integration of several companies specialized in different valences, in a national consortium that allows the construction of 3 types of carriages to produce an innovative and highly sought after "Portuguese train". Thus, the final product resulting from the project, intended for future commercialization by the project leader, consists in the production of a composition of 3 vehicles in a typology of three carriages namely a pilot carriage plus 1st class; a 2nd class carriage plus bar; and a 2nd class carriage.
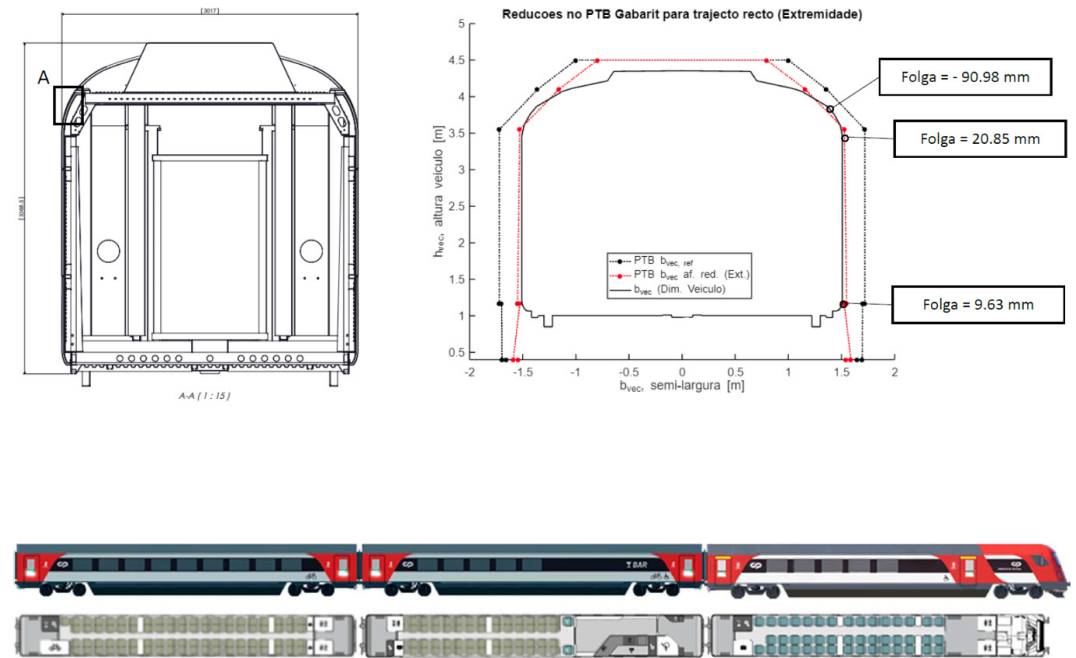
Circular2B — Circular construction in modular and energy-efficient buildings

Principal Investigator
Nuno Ramos

Total funding
126 688 €

Source of funding
Mecanismo Financeiro do Espaço Económico Europeu

The construction industry has a high consumption of materials and energy which, has a very significant impact on CO2 emissions. The productive and construction industries are the ones that most contribute to the increase of these emissions (about 20% of the total). In addition, the construction sector has a major impact on the global economy, contributing about 10% of GDP. The implementation of the principles of circular economy, namely through the reduction of waste and pollution, the increase of the durability of solutions and the regeneration of natural resources, allowed the definition of concrete measures in the built environment, such as the increase of GDP, the reduction of greenhouse gas emissions and reducing the consumption of raw materials (Circular Economy Action Plan). In this sense, this project aims to combine energy efficiency with waste recovery, namely plastics and C&D wastes, and the increase of prefabrication in the construction industry. The focus on prefabrication (modular construction) is supported by the fact that this type of construction considerably reduces the RCD.

Circular Construction in
Energy-Efficient Modular Buildings
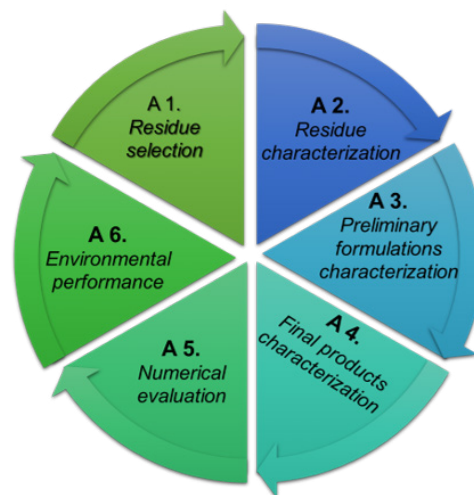
SUDOE ENERGY PUSH — Efficient Energy for Public Social Housing

Principal Investigator
Nuno Ramos

Total funding
211 061€

Source of funding
European Commission

SUDOE ENERGY PUSH (Efficient eNERGY for PUblic Social HOUSING) is an innovative project that aims to implement an energy management model for Social Housing facilities located in the SUDOE territory, positioning itself as a reference in increasing energy efficiency and quality of life for less favored citizens. Based on the combination of passive renovation concepts, based on the NZEB principle (Nearly Zero Energy Buildings), whose main objective is to minimize the energy needs of buildings, and on the BIM methodology that favors joint experimentation, appropriate energy solutions will be proposed and directed to Social Housing in the SUDOE space. In this way, ENERGY PUSH will thus achieve a double objective: on the one hand, to reduce energy consumption and CO2 emissions, and also to improve its thermal comfort, providing its residents with a better feeling of comfort at different times of the year, reducing the risks of energy poverty.
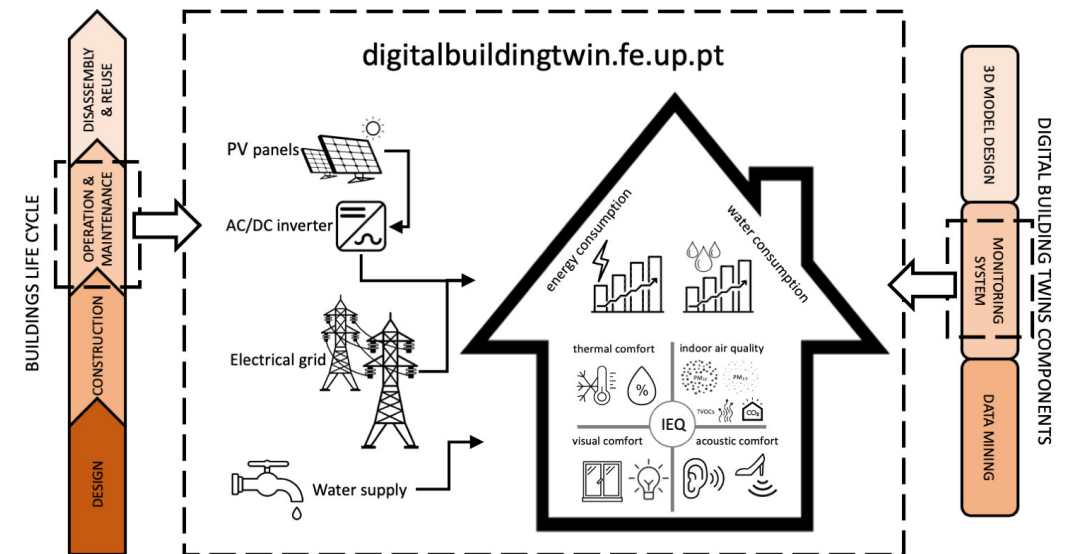
SUDOE STOP CO2 — SUDOE Stations of Transport OPposed to CO2

Principal Investigator
Nuno Ramos

Total funding
199 247€

Source of funding
European Commission

The urban centers of European cities concentrate the majority of services to citizens, including buildings and infrastructures unlocked for the inland transport of passengers (intercity bus stations, trains, etc.). cities and their surroundings, it is generally called not inland from urban centers because of the need to bring transport closer to the citizen and to facilitate access to public transport. Despite this, contrary to their original purpose, these public infrastructures are a focus of extremely high energy consumption and displacement of greenhouse gases, which affect both citizens, as well as the image of the city and public transport. Transport stations are obliged to consume enormous amounts of energy (lighting and electricity, air conditioning, gas regulation and dispersion systems, water, etc.) and, in general, from their construction to their operation, they present notable deficiencies. contents to energy management, so it is necessary to take actions that reduce the energy bill and the environmental impact. Many buildings and infrastructures are outdated, but they present great opportunities to apply renewable energies and stimulate the transfer of innovative techniques, their valorisation and application. This situation is widespread in the SUDOE territory. Virtually all cities and urban areas with more than 15,000 inhabitants have at least one bus and / or train station. Taking into account the configuration, structure and operational management of the centers at the energy level, the concentration of vehicles around these centers and an inefficient connection with urban transport, are a clear environmental problem. In this way, SUDOE-STOP-CO2 (European Union Stations of Transport Opposed to CO2) proposes an energy solution for stations and passenger transport in urban centers in the SUDOE territory, as a way to achieve a reduction in CO_2 transfer in cities , increase energy efficiency, promote the use of public transport and change the behavior of citizens in terms of energy. SUDOE-STOP-CO2 activities framed in the following performance vectors: a) Include transport centrals / stations as an objective of local sustainability policies, not only as an anchor point linked to the mobility chain, but should be considered as an essential and differentiating element to the global efficiency of urban centers; b) Dissemination of good practices and carrying out pilot actions through innovative techniques (3D systems and BIM; Building Information Modeling / Management) to reduce the energy bill of these buildings (stations and terminals) through the use of renewable energies and improve management, looking for more ecological and sustainable focuses from an environmental point of view, as an example for other sectors. c) Creation of an energy certification tool for stations through 3D and BIM systems, in order to be able to determine their situation in relation to energy consumption and the solutions to be applied in each one. d) Elaboration of recommendations for Public Administrations in general and agents of the transport sector in particular.
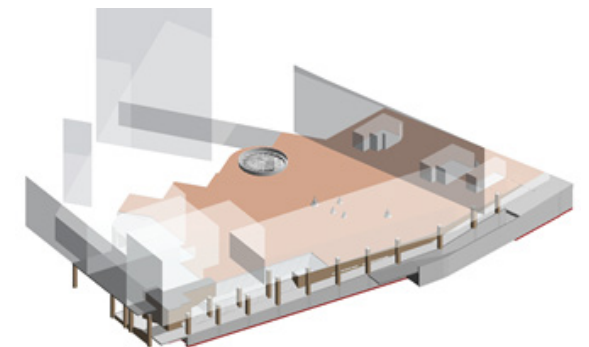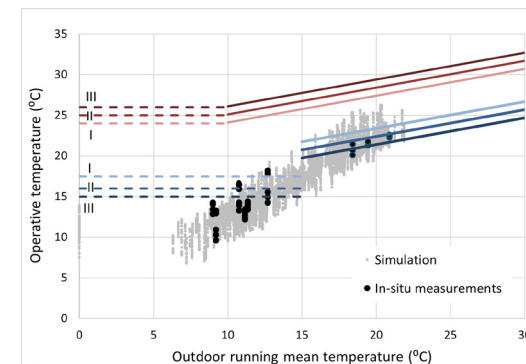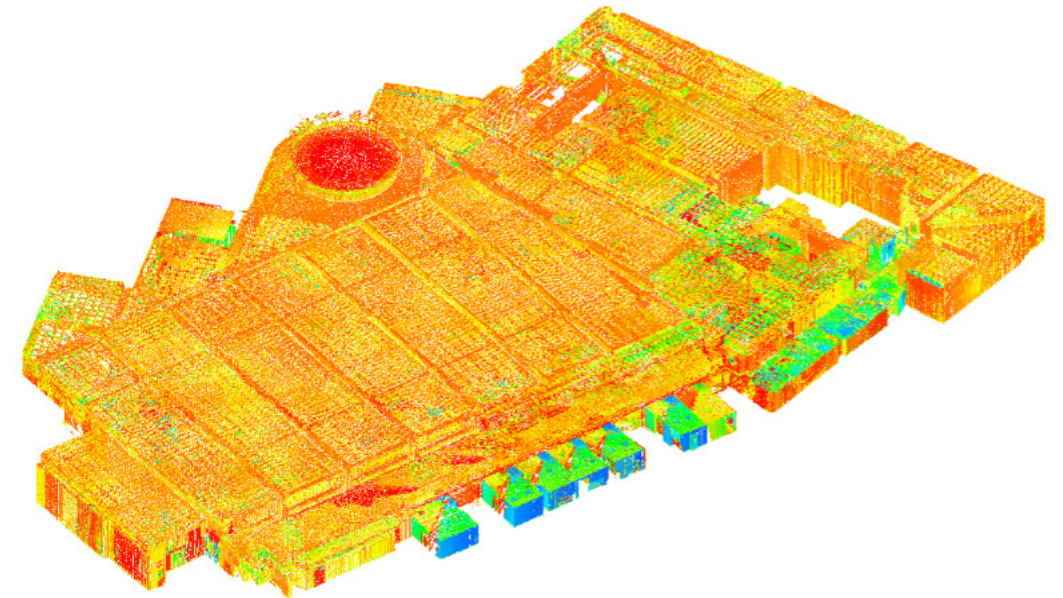
EnReflect — Envelope systems with high solar reflectance by inclusion of nanoparticles

Principal Investigator
Nuno Ramos

Total funding
158 342€

Source of funding
FCT - Fundação para a Ciência e Tecnologia

The main goal of this project is to improve envelope systems by increasing their solar reflectance through new material formulations with the inclusion of nanoparticles on typical envelope systems. If the near infrared (NIR) solar absorption is reduced, the referred benefits can be achieved even in darker colors. The proof of concept will be performed in ETICS and Thermal renderings. The expected results of the proposed research are:

· Affordable nanomaterials compatible with ET-ICS and Thermal renders that can provide a relevant reduction of their solar absorption;

· Detailed surface hygrothermal numerical model and coupling to existing building simulation tools;
· Validation of the numerical model with in-situ tests;
· Durability assessment of the nanomaterials application.

The strategy is to start at basic research and move to a TRL4 level where the small scale prototypes will demonstrate the benefits, in terms of energy efficiency, of using new nanomaterials in buildings.
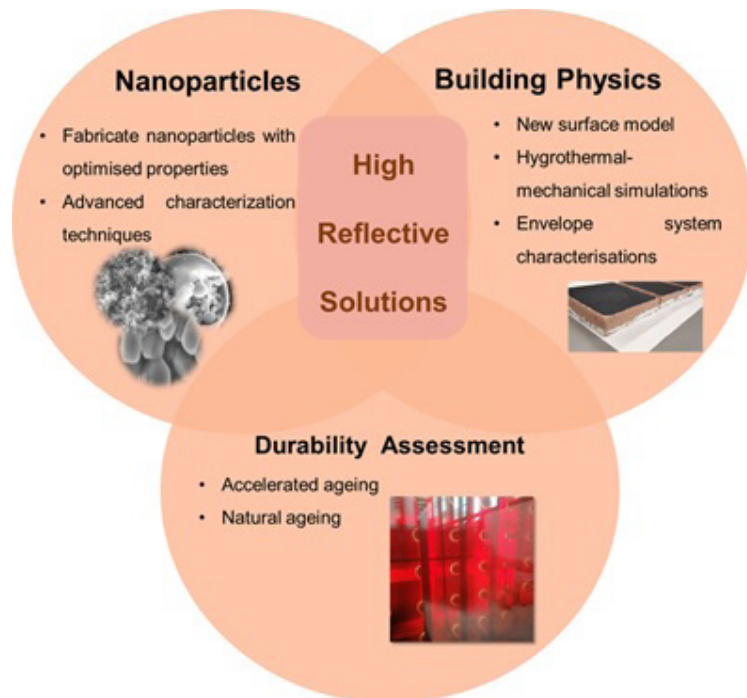
GrowingCircle — Integrated Data for Efficient and Sustainable Construction

Principal Investigator
Hipólito Sousa

Total funding
359 481€

Source of funding
EEA Grants 2014-2021 - Environment, Climate Change and Low Carbon Economy Programme

Digitalization trends in the construction sector point to processes and technologies that promote the collection, consistency, integration, management, traceability, and maintenance of the information about constructed objects as well as the construction products that compose them.

The systematization of data and its conversion into information blocks must consider the needs of the stakeholders involved in the construction process as well as the construction life cycle phases.

It is imperative for the dynamics of circular economy in the construction sector to ensure the circularity of information about build objects and its elements.

Data Templates are standardized and interoperable metadata structures with the capability of responding to the abovementioned needs, contributing to the effective implementation of more circular, more efficient and environmentally friendly practices. Data Templates are Digital Product Passport enablers.

The GrowingCircle project aims to raise awareness among agents, through training/dissemination actions for the (fundamental … core … essential …) role of Data Templates and evidence their impact through practical implementation in specific case studies.
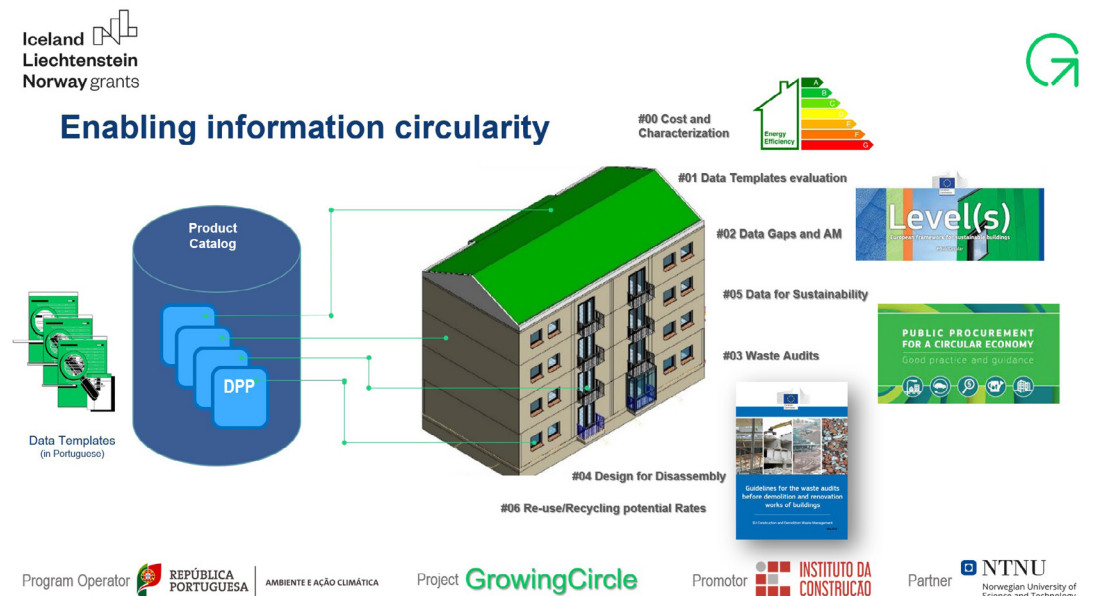
BlueWoodenHouse — Modular Wooden House Grid-Off and Low Water Consumption

Principal Investigator
João Delgado

Total funding
534 965€

Source of funding
Agência Nacional de Inovação S.A.

Is it possible to build a house that is energetically autonomous and cheaper than the ones connected to the electricity grid? Under certain conditions the answer is: yes, it is possible. The project BlueWoodenHouse aims the developing, construction and evaluation of the first energetically autonomous modular wooden house, off the electrical and gas grid, with a TCO (Total Cost of Ownership) lower than the equivalent conventional houses. Moreover, the new house should be designed to have water consumption, by the public grid water supply, below 50 % of the current value, which is around 100-120 liters/p.person/day. To make this possible, the proposing team has designed an effective set of passive and active solutions that it now intends to materialize, characterize, optimize and validate, while developing the tools that will make the autonomous house a current and desired practice in Portugal and in the world. The project aims to characterize/monitoring a reference house built by the company leader of the consortium, with about 100m2, inhabited by a family of 2-4 people and built after 2015. The evaluation of the autonomous house to be built (prototype house) will thus be evaluated against the data collected from reference house; the prototype house will be built in the same region as the reference house. The prototype house will respect the Portuguese legislation for NZEB Buildings (2018/844/EU and Regulations 98/2019), and intends to go a lot beyond this objective. The project will develop numerical simulation tools that will allow the design of a house with a defined probability of never having a nominal consumption higher than the hourly energy production. This new tool takes advantage of the average and variance of climatic data over the past 10 or more years. The project ambition, which will rely on the determination of other sustainability indicators, will allow the promoting company to become a market leader in Portugal, in Southern Europe and around the world.

Home Zero · Smart Modular Houses

Principal Investigator
Nuno Ramos

Total funding
192 944€

Source of funding
Agência Nacional de Inovação S.A.

The longing for revolution driven by the environmental challenges faced by modern society led to the development of the Project HOME ZERO. The Project ZERO HOME aims to develop technologies and innovative systems in the construction field that encourage sustainability and independence of the external power supply networks through the use of centralized intelligent management, the use of local renewable energy production systems and energy storage systems, in association with constructive and architectural solutions that optimize energy efficiency, resulting in energy balance very close to zero (NZEB). The multidisciplinary nature of the integration of advanced building technologies along with energy sustainability aspects in the development of the construction sector provides to the project a potential for development of scientific knowledge and transformation of the construction sector. Thus it is intended to promote the optimization of energy costs of buildings throughout their life cycle and the profitability of means and technologies available to mitigate environmental problems and promote progress towards the comfort of the users allied to the maximum utilization of available renewable natural resources. To this end the Project includes the construction of a prototype to test and demonstration of results that improve the perception and dissemination of created evolution.

BlueHouseSim — Development of numerical simulation tools and methodologies for high-efficient off the electrical grid houses

Principal Investigator
Vasco Peixoto de Freitas

Total funding
49 947,77 €

Program
I&DT

Source of funding
FCT - Fundação para a Ciência e a Tecnologia

The Project BlueHouseSim aims at developing numerical simulation tools and methodologies that will allow the design of off-grid houses based on solar energy as well as contributing to the public accessibility of future homes, implementing the new Directive 2018/844/EU. These new numerical tools will be experimentally validated and then inserted in available simulators such as Energy-Plus; these tools cover innovative approaches for decreasing energy needs and better taking advantage of the energy from renewable sources. The new simulator will use average and variance climate information to produce a statistical model. To minimize storage costs, a management algorithm will be developed to eliminate less critical consumption whenever energy availability is approaching the critical region. Also, both thermal and electrochemical storage will be smartly optimised; a biomass boiler will be considered for providing thermal energy during these critical days. Algorithms that take into account weather forecasts and house usage (e.g. parties) will be developed/integrated as well. The new simulator will be used to design, validate and optimise an off-grid house, under construction by Black Oak Company, BOC, with a Total Cost of Ownership (TCO) lower than that equivalent conventional house. The proposed team intends, now, to characterize, optimize and validate. It is the emphasis on the TCO that makes this project unique, ambitious, and at the same time so relevant. An off-grid prototype house, with 140 m2, will be analysed and adapted to study the integration of photovoltaic (PV) panels and skylight on the roof (BIPV), optimization of the roof slope and the airflow that passes under PV panels - ventilated PV roof. This prototype house will allow to study and optimize these and other construction solutions for achieving the lowest TCO, besides being very instructive, especially for engineering students. The developed simulator and new numerical tools will be validated against the experimental data and the simulator will be made available for national and international users. All designed off-grid houses will respect the legislation for nZEB's, and go far beyond this objective, with consumes near 15 kWh/m2/y, significantly lower than 40 kWh/m2/y, mandatory from 2021 on. Preliminary results show that it is possible to build an off-grid house with a lower TCO as long as the excess electricity is sold at ›5 C€/kWh - an appreciation of 10 C€/kWh is expected based on sales to neighbours. The present set objectives are quite realistic and very innovative; they are a step forward of directive 2018/844/EU and applicable to the buildings of the European Southern countries such as Portugal, Spain, Italy and Greece. The project ambition includes also the determination of other sustainability indicators, such as EROI (Energy Return on Investment). The objectives proposed here are realistic, innovative and extremely relevant for energy decarbonization; they go beyond directive 2018/844/EU applicable to buildings in southern European countries. The project BlueHouseSim aims to contribute to the fast implementation of PNEC 2030 and 2018/844/EU and wants to demonstrate that energy should be not just "green" but "blue": "green", low cost, and aesthetic. Only "blue" houses will attract householders, investors and builders and the change for the energy decarbonization will happen fast and "naturally.

Year	Project	Contracting entity	Principal Investigator
2022-2023	Diagnostic and intervention methodology study of the Fafe Palace of Justice building, FEUP/LFC	IGFEJ - Instituto de Gestão Financeira de Equipamento da Justiça	Vasco Peixoto de Freitas
2022-2023	Diagnostic Study and Intervention Methodology in the Fonte Luminosa Leiria Car Park, IC/LFC	SABA	Vasco Peixoto de Freitas
2022-2023	Diagnostic Study and Intervention Methodology of the Cloister of the Criminal Investigation Department Building of Aveiro – Judiciary Police, FEUP/LFC	IGFEJ - Instituto de Gestão Financeira de Equipamento da Justiça	Vasco Peixoto de Freitas

TherBlock3Dp — 3D printing of thermal blocks

The European Commission reported that buildings are the single largest energy consumer in Europe and the overconsumption of non-renewable resources that leads to resource scarcity, the growing consumer's requirements, climate change and the increasing need for rapid urbanization. Thus, it is important to establish more efficient construction methods that are able to overcome the lack of interoperability and productivity currently present in the construction sector {1-2}. Over the past few decades, building processes have been fundamentally based on manual labour, which is one of the reasons why the construction industry is regarded as low tech with low levels of innovation. When compared to traditional methods like casting concrete in formwork, construction 3D printing (c3Dp) has revealed important economic, environmental and constructability advantages, such as reduction in building time and waste, mass customization and complex architectural shapes. Furthermore, c3Dp is pointed out as a promising trend of the future in the Digital Transformation in industry, due to the potential association of 3D printing with Building Information Modelling (BIM) and artificial intelligence (AI) {3} Overall, a lack of knowledge related to the thermal behaviour of additively manufactured building elements was verified {4-8}, mainly due to the fact that research projects are at an early stage of application, focused on structural design and durability concerns. However, with the fast evolution of additive manufacturing methodologies for building construction, thermal insulation represents a knowledge gap that must be closed. In this exploratory project, a masonry block/panel with improved thermal behaviour will be developed using a construction 3D printing technology. It is intended to explore the thermal behaviour of additively manufactured building elements finding measures/solutions to improve it {A-E}. For that, the incorporation of thermal insulation materials and different geometries will be evaluated. In a first stage the basic solution of masonry concrete block will be printed and tested in laboratory to evaluate its thermal properties. The experimental results will be used as inputs in a 2D/3D thermal simulation software {D-E}. The same software will then be used to optimize the thermal behaviour of the block/panel, by changing the geometry and the materials of the basic solution. Finally, the optimized solution will be printed and new tests will be performed to validate the numerical results. After this important step, it will be possible to act in the mixture and develop a thermal block/panel with a single material or adding thermal insulation materials or additives to the 3D printed mix. To be more ambitious and considering the importance of a circular economy, the incorporation of waste materials in the block, acting as thermal insulation, will be analysed in order to invest in three important goals: Digital Transformation in Civil Industry, Energy Efficiency and Circular Economy.
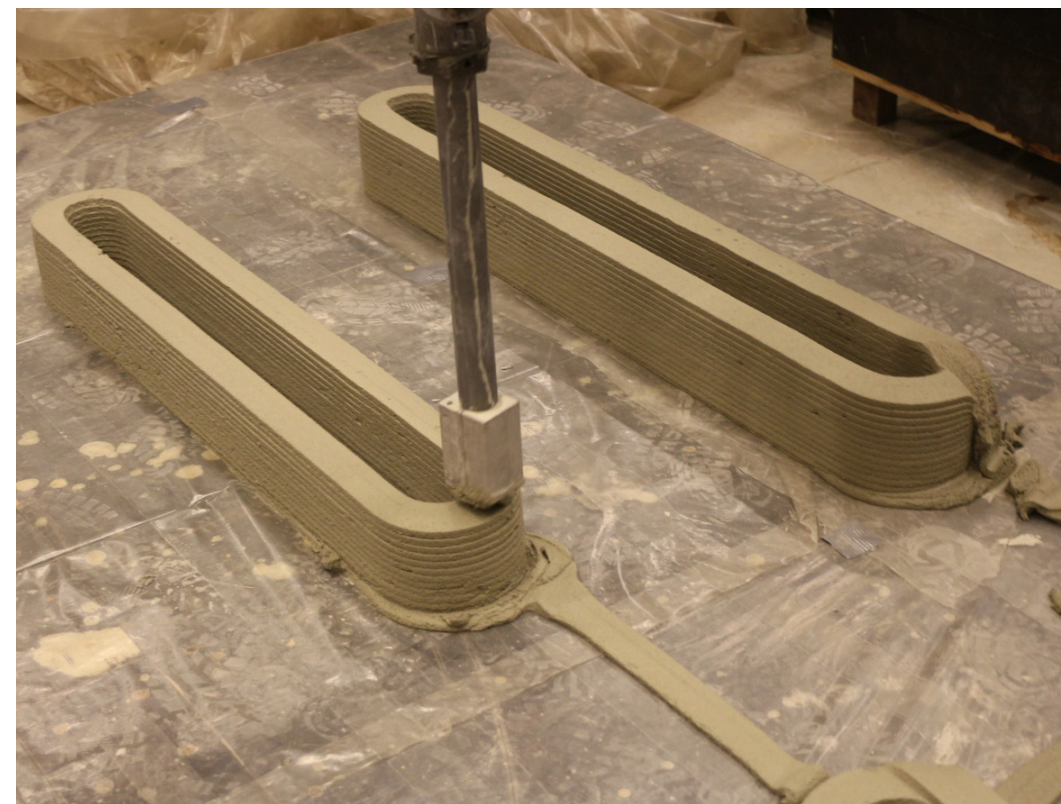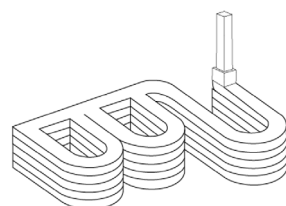
REV@CONSTRUCTION — Digital Construction Revolution

Principal Investigator
Hipólito Sousa

Total funding
FEUP/IC 202 906,68 € / 321 660,74 €

Source of funding
Agência Nacional de Inovação S.A.

General objectives: - Digital transformation of the Construction industry; - To develop efficient collective actions towards the reinforcement of innovation, empowerment, promotion and internationalization of the Construction industry. The project is structured in 4 PPS (Products; Processes or Services) and IC/FEUP and FEUP are participating in multiple Activities of PPS1, in which it is intended to create the bases for the digitalization of the industry. Following up on the work developed during the ProNIC project, IC/FEUP and FEUP are developing activities in the areas of:

· Typification of Construction Works Templates and Standardization of Information;
· Cost Databases and Development of Interoperability Mechanisms between Platforms and Connection with BIM.

Results/Impacts:

· The expected result of PPS1 is the development of an interoperable platform (Digi4Construction) that will contain a repository of normalized technical information, technical and economic indicators that can be used in the throughout the industry;
· Contributions for Increasing the efficacy and efficiency of public and private construction works processes;
· Reducing “public context costs”
· Through uniform practices and procedures over the different stages of the building process;
· Increasing the use of innovative information and communication technologies in the Construction industry;
· Promoting the qualification of public investment in Construction and using interoperable platforms.

STEPS — Advanced Production System for the Built Environment Focusing on Productivity and Sustainability

Principal Investigator
Rui Calejo

Total funding
258 172€

Source of funding
Agência Nacional de Inovação S.A.

STEPS consists on development of a new advanced building production system that allows to reduce or even eliminate the environmental impact of an entire production chain that integrate and feed the construction sector and substantially increase the productivity in the construction industry. This system depends on the investigation and development of a specific technological solution (houseFIT system) — a technological system of prefabricated components with a high level of automation, lightweight and reduced dimensions, which together allows the complete production of buildings in self-construction or using robotic labor.

REV@CONSTRUCTION
DIGITAL CONSTRUCTION REVOLUTION

DigiCrete — Next Generation of Digital "Concrete": performance mix design and assessment of sustainable and circular cementitious composites

Portland cement (PC) is currently a massive construction material. No alternative is expected to arise, meeting our societies' legitimate needs for infrastructures, housing, and improved living standards. Our civilisation relies on the broadly available and, thus, inexpensive inorganic binder that hardens rapidly in most habitable environments, as well as underwater. It can be used in a broad range of construction and civil engineering works. However, its increasing consumption turned it into a serious problem. This is mainly because producing a ton of PC requires around 1.7 tons of non-renewable natural materials and 4 GJ of energy. Besides, cement production is responsible for using 7 billion tons/year (of which 13 million tons in Portugal) of non-renewable natural materials, 2% of the global primary energy consumption and 5% of the global industrial energy consumption. Nevertheless, the International Energy Agency Cement Roadmap projects growth of cement demand by 12%-23% by 2050 and the OECD admits that its demand might double by 2060. Thus, cement-based materials are essential for achieving the United Nations Sustainable Development Goals since they have social, economic and environmental effects.

Innovative construction technologies and developing greener cement-based materials are considered effective methods for promoting energy conservation and reducing carbon emissions associated with construction. The introduction of digital fabrication processes for construction, namely 3D Printing of cement-based materials (3DPC), usually mortars, has demonstrated that a well-developed digital/automated process can provide substantial benefits to the construction industry, such as the freeform architectural design without formworks. Increased productivity, reduced costs, and more safety worksites are potentially expected, as environmental benefits within materials savings and waste generation reduction {21}. However, 3D printing technology imposes new requirements on material properties. 3DCP demands high flowable performance from the printer pump to the nozzle. Simultaneously, the printable materials should reveal high buildability to maintain printed shape and printable layers without collapse. Such behaviour is accomplished by mixture design, which employs more fine materials (cement+supplementary cementitious materials) and chemical admixtures (superplasticiser, VMA, HEMC), increasing CO2 emissions and energy consumption compared to traditional casting concrete.

Therefore, from a materials science view (and not only), 3DPC faces significant challenges. It is necessary to solve the problem of material clogging to required engineering printing properties while keeping robust, sustainable, circular cementitious-based mixtures. The main goal of DigiCrete is to develop environmentally friendly cement-based materials that can satisfy the requirements for 3D Printing. Sustainability is pursued via the partial replacement of a significant fraction of the cement with locally available waste materials with no added value, namely glass powder, marble powder and quartz powder, which already show promised results in previous works.

At first, a methodology will be developed using the design of experiments approach (DOE) for formulating sustainable ternary blended binders suitable for laboratory scale 3D printing of cement paste, seen as a first step towards the larger-scale 3DPC. Using DOE, the paste mixture parameter (input) will describe the workability, rheology, hydration knicts, visco-elastic and mechanical properties through combining statistical methods, regression analysis and optimisation techniques, and achieving the multi-printable performance requirements. After establishing the best combinations of cementitious materials, water and admixtures, a mortar-level study will follow also using DOE. Predicting mortar behaviour based on paste properties will significantly simplify the 3DPC design. This will have a key role in evaluating the printability window (open time) and establishing printability criteria which can be used as a control quality measure.
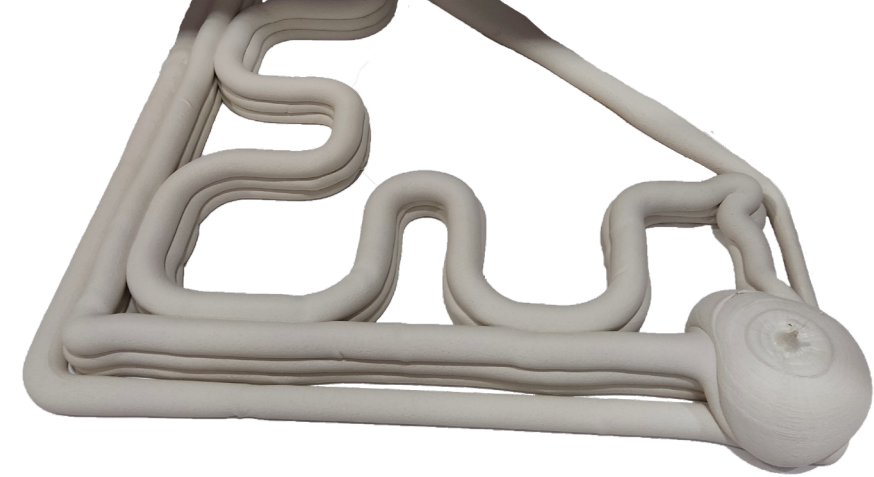
However, it is the final product properties and conformity to design that give the manufactured component value. If the 3D printing method is to become standard practice, engineers will need to understand how to design structures to be manufactured with printed materials, leading to new design codes and standardised testing methods. Thus, slabs will be printed using optimal mixtures, and conventional casted specimens will be produced. Meso-level characterisation will follow by checking the inter-layer connection, and the mechanical behaviour of printed specimens in the orthotropic directions will be assessed and compared with conventional casted specimens of the same mixtures.
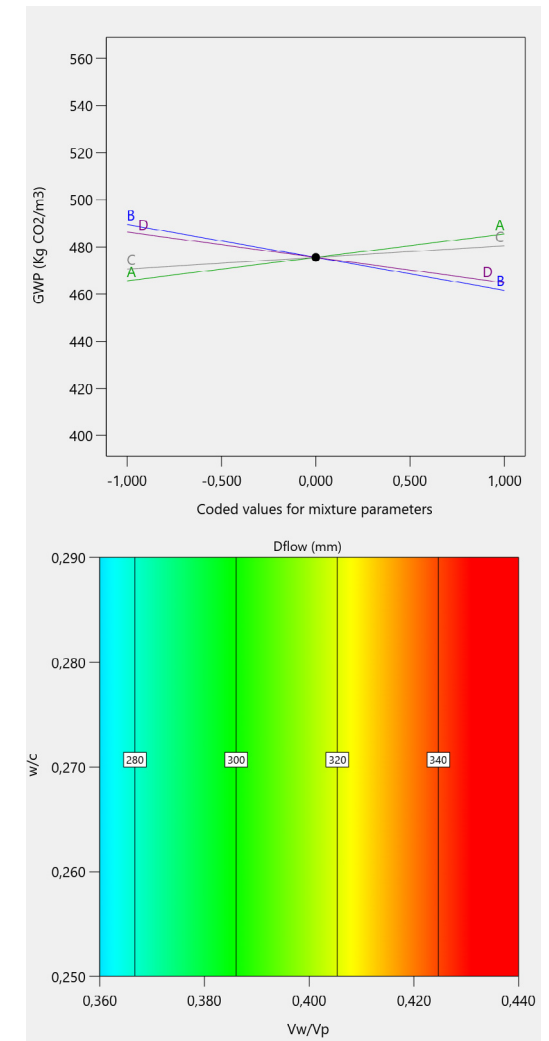
CSETIR — Safety in Construction using Immersive Reality in Education and Training

Principal Investigator
Alfredo Soeiro

Total funding
103 492€

Source of funding
European Commission

Construction sites are dynamic and complex environments, making them difficult to control and monitor. Construction safety prevents people from dying or becoming incapacitated. It is a socially relevant issue that persists despite several initiatives. It is also an economic problem that costs about 4% of the world PIB. Also, it is not acceptable in the XXI century for a worker to die while working. Challenges are especially significant for new and illiterate workers due to lack of training. Injuries and accidents occur because there is no proper preparation for workers. Each construction site is different from any other, therefore it is necessary to train technicians, workers and engineers to the exclusive and potential risks that may arise from each new environment. To cope with the pressure of avoiding accidents development, safety can no longer rely on traditional accident preventions measures. CSETIR (Construction Safety with Education and Training using Immersive Reality) arises from the synergy between higher education institutions and construction company provider to implement the use of smart technologies in proper training. The digital tools allow the creation of instruments that simulate construction scenarios allowing the identification and prevention of risks for teachers, technicians, and engineers. This proposed project aims at enhancing knowledge exchange between representatives of three sectors to innovate the accident prevention approaches through effective collaboration between researchers in the virtual reality filed and construction companies. CSETIR partnership will develop innovative and interactive VR/AR (Virtual and Augmented Reality) solutions to prevent accidents and train workers. CSETIR intends to create usable tools for teachers, technicians, and engineers that will be used in any construction project. CSETIR also aims at offering training sessions online on an online platform (project website, wiki) to grant learners and trainees access to interactive material and resources. These tools will range from applications to be used on smartphones to virtual reality contexts depending on the needs of training.

CSET r
Construction Safety with Education
and Training using Immersive Reality
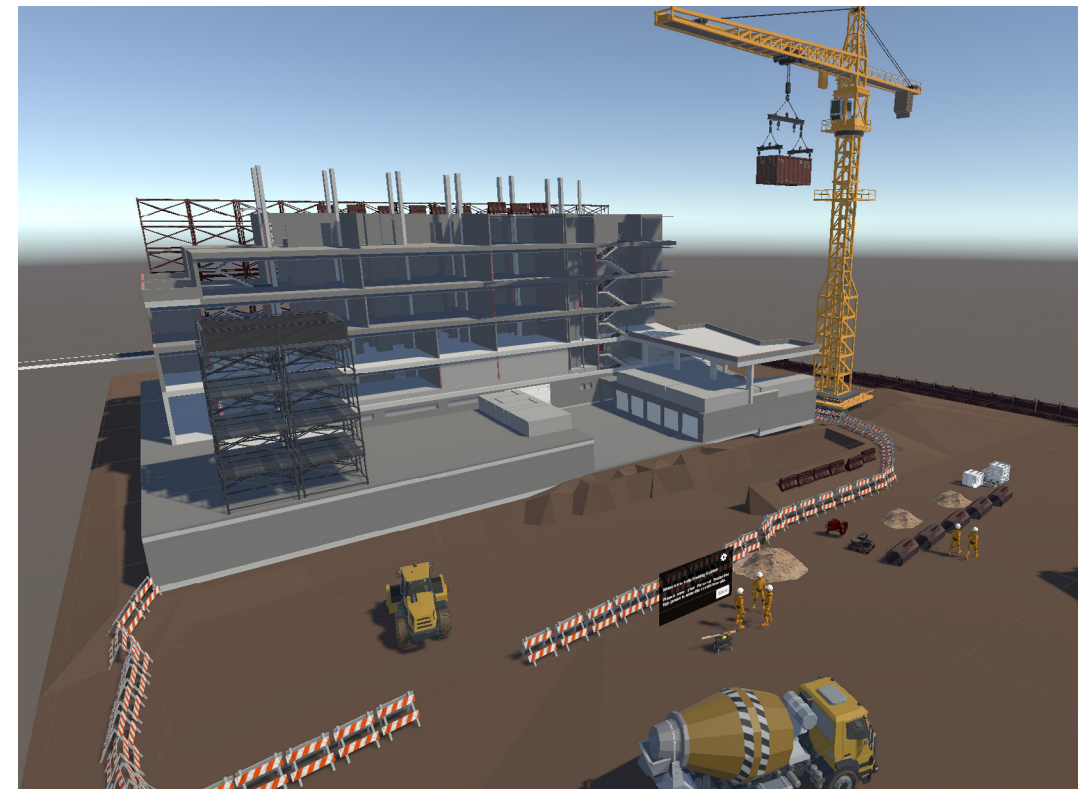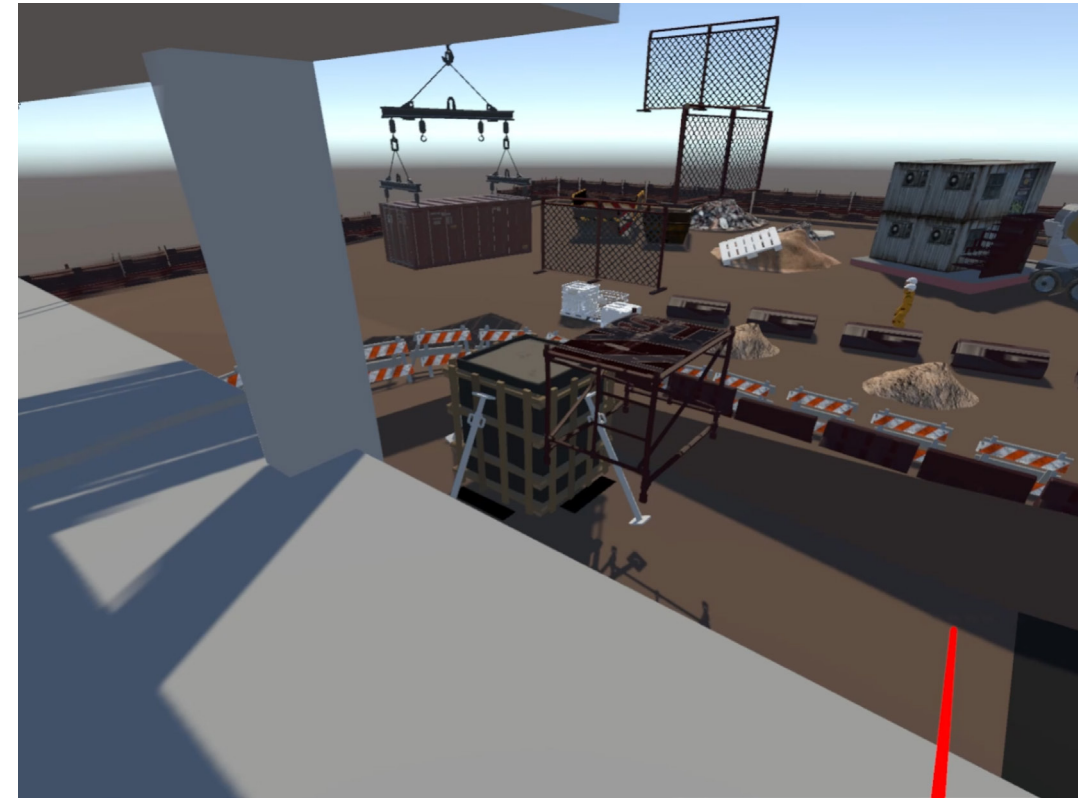
ELBigMAC — ELBigMAC · Educational Lab – Big Machine

Principal Investigator
Bárbara Rangel Carvalho

Total funding
69 045€

Source of funding
European Commission

Educational Lab Big Machine, ELBigMAC is an ERASMUS + project developed by the University of Porto in Portugal, the University of Zagreb in Croatia and the Aristotle University of Thessaloniki Greece, with a main objective of disseminating Civil Engineering activities among the pre-university students. The main vision is that a House is, in fact, a Big Machine with different layouts and forms, and with this project, is intended to demonstrate the different steps that are necessary to make it, from design, to research, to construction until its performance. The activities proposed to the students cover the different phases. The design phase activities includes building physical models, Virtual Reality models, BIM modelling, augmented reality sandbox and others. In the research phase the students build prototypes of construction systems and test them in the University laboratories. To understand the construction phases the students are also invited to participate in sustainable construction workshops, and then test in the Big Machine House, the performance of their solutions. As an educational laboratory this is an innovative way of teaching / learning about Civil Engineering as well as a tool for supporting High schools in their efforts to guide secondary students' interests and decisions regarding higher education.

COMPLEX TRAJECTORIES — Successful trajectories in Higher Education Institutions

Principal Investigator
Alfredo Soeiro

Total funding
22 472€

Source of funding
European Commission

Relatively little attention has been given to the progression of students through their studies. When it has been done, we see that it focuses on a unique HEI and adopts a perspective of efficiency, which ends up proposing retention policies. We intend to broaden the scope in various ways. Firstly, if the angle of vision of the trajectory followed by a student, rather than that of the particular HEIs, was that of the system, then the definition of "success" would probably be given by the completion of a university degree at the end of its trajectory, regardless of whether this has been more or less complex. From a systemic point of view, it makes sense that even a complex trajectory can be a path to success. Second, most HEIs that have data on their students' progress develop the relevant indicators to pass the assessment processes of their degree programs. The perspective behind such indicators is usually one of efficiency, but rarely one of equity. However, one of the most widely accepted missions of the university is to promote equity and social cohesion. In fact, since the Prague communiqué in 2001, the social dimension of higher education has been one of the elements that have been insistently pointed out as being fundamental for the construction and consolidation of the European Higher Education Area (EHEA). It is therefore essential to pay attention to the particular trajectories of disadvantaged groups and to compare their trajectories in different contexts. Finally, with a wider definition of what can be considered a success, and the stress on equity perspective, policies of retention must also be widened. The monitoring of student trajectories should provide information on the socio-demographic and academic characteristics of the student and information at the system level, in order to capture transfers between degree programs and universities. At the HEI level, this broader perspective should lead to the implementation of policies that assist student decision-making and support the path he or she ultimately decides to follow. In this context, this project aims at identifying patterns in the trajectories of university students and to assess their probability of occurrence as a function of the socio-demographic and academic profile of the students and the institutional context. Particular attention will be paid to the trajectories resulting from a transfer process between degree programs and universities, especially if the transfer is made from a face-to-face university to a distance university. This project also aims to contribute to the compilation and dissemination of policies that support the progress of students, with particular attention to those that help them transfer from one program to another or from one educational institution to another. Finally, the project aims to develop and extend a series of tools aimed at different agents in the university, in order to: a) develop a certain awareness that it is necessary to work in a new framework of complex trajectories; b) implement systems to help students build their own trajectories (be it progress, decision making, shift, etc.).

CALOHEE — Comparison of Learning Outcomes in Higher Education in Europe

Principal Investigator
Alfredo Soeiro

Total funding
18 000€

Source of funding
European Commission

Achievements of Learning Outcomes in Higher Education in Europe. These outcomes are conceptual qualifications and assessment frameworks for five subject areas, chosen to represent significant academic domains: Engineering (Civil Engineering), Social Sciences (Teacher Education), Humanities (History), Health Care (Nursing) and Natural Sciences (Physics). The frameworks are flexible reference documents, which offer detailed insight into what students are expected to learn to be prepared well for their future role in society, both in terms of the workplace and civic, social and cultural engagement. They also offer a robust basis for comparing students; performance in European wide context. The instruments allow for precise measurement, while taking into account the different missions, orientations and profiles of Higher Education institutions and their degree programmes.

CALOHEA — Measuring and Comparing Achievements of Learning Outcomes in Higher Education in Asia

Principal Investigator
Alfredo Soeiro

Total funding
25 789€

Source of funding
European Commission

The CALOHEA project seeks to contribute to the internationalization of higher education institutions through developing a series of interrelated measures indispensable for improving recognition of higher education degrees and, thus, not only enhancing mobility within the South East Asian region, but also facilitating mobility from the EU to South East Asia and vice versa.

EU3Digital — Developing a European framework for digital competences for adult education organisations

Principal Investigator
Alfredo Soeiro

Total funding
49 019€

Source of funding
European Commission

The recent COVID-19 pandemic and the quarantine measures imposed in the majority of European countries have highlighted a fundamental necessity of third sector social organizations (TSS): the capacity for the strategic & effective use of digital skills and technologies (DST).TSS working with vulnerable groups are having to quickly adjust their modus operandi in order to i) keep providing key services while promoting the safety of their target groups&staff; ii) create innovative solutions for new challenges and iii) ensure their sustainability within this unprecedented context. Moreover, there is a pressing need to align strategies & procedures between governmental, private and third sectors, in order to i) address current challenges; ii) prepare for future scenarios where contingency measures might need to be put into place and iii) maintain transparent collaboration and democratic governance. EU3Digital is an international resource designed to develop more strategic and integrated use of digital competences in order to improve basic & transversal skills of third social sector leaders, employees, and young professionals. This program will make pre-existing training materials on TSS specific competences available on an open-access knowledge centre. It will make available a kit of tools and methodologies designed to prepare TSS organizations for the need to build customized contingency plans that promote effective inter-sectorial collaboration.

ACE — Student-Focused Learning in South America

Principal Investigator
Alfredo Soeiro

Total funding
8 958€

Source of funding
European Commission

Building on the work that has been established in Latin America and beyond, the proposed project intends to fill the gap between theoretical models and educational practice. To this purpose it will develop through a grass root approach implementation structures, models and examples of good practice for staff development, which can be tailored to national and institutional needs. These should be applicable throughout the Higher Education sector. Four subject areas have been selected to take the lead, covering as many academic sectors: Environmental Engineering, Education Sciences / Teacher Training, Nursing and History. These fit the new priorities that have been identified for Latin America with regard to Capacity Building projects in December 2017. In the framework of the project transnational working groups will be set up to develop best strategies for staff development for the (re-) design, the implementation and evaluation of individual degree programmes. It will also describe examples of good practice for developing the different competence clusters as described in the Latin America meta-profiles. Use will also be made of the outcomes of the sophisticated project Measuring and Comparing Achievements of the Learning Outcomes in Europe (CALOHEE) (2016-2018) that defined Assessment Frameworks and student-centred based examples of good practice for learning, teaching and assessment.
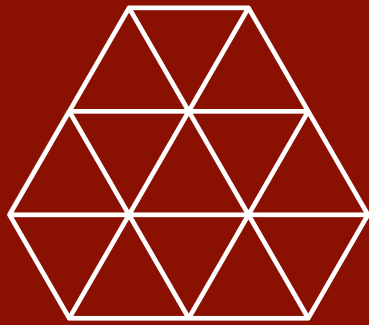
RELEVANT
CONSULTANCY
PROJECTS

Relevant Consultancy Projects

Year	Project	Contracting entity	Principal Investigator
2015-2023	Continuous Dynamic Monitoring of Baixo Sabor and Foz-Tua Dams	EDP / ENGIE	Álvaro Cunha
2018	Design studies for a tuned liquid damper to install in a steel chimney for a HRSG located in Rades, Tunisia	Taylor Devices	Elsa Caetano
2018	Continuous dynamic monitoring of Foz-Tua road and railway bridges	EDP	Álvaro Cunha
2018-2019	Management of the continuous monitoring system installed at the Braga Municipal Stadium	Academia Bernardo da Costa — Formação e Consultoria, Lda	Elsa Caetano
2019	Measurement and assessment of vibrations induced by construction works in the context of the rehabilitation of the Mercado do Bolhão in Porto	Lúcio e ACA - Bolhão ACE	Carlos Moutinho
2019	Assessment of the stability of the FEP obelisk	FEP	Elsa Caetano
2019	Study of buffeting effects during the construction stage of the Randselva Bridge	Armando Rito	Elsa Caetano
2019	Development of displacement sensors for the test of bridges in Turkey and Peru	BERD	Carlos Moutinho
2019	Dynamic testing of suspended floors of the New Terminal of the Geneve Airport	Martifer	Elsa Caetano
2019	Study for the damping control of galloping cable vibration of the Gordie Howe International Bridge, US-Canada	AECOM	Elsa Caetano
2020	Design of a damping solution for a clinker transport bridge in Abidjan	ProIndustrial	Elsa Caetano
2020	Essais vibratoires aiguilles - Torre Trinity - Paris	Bysteel	Elsa Caetano
2020	Supply, configuration and operation of a monitoring system for a wind Turbine	EDP Renováveis	Filipe Magalhães

Relevant Consultancy Projects

Year	Project	Contracting entity	Principal Investigator
2020	Instalation and test pf monitoring equipement in a wind turbine at Parque Eólico de Serra d'el Rei	EDP Renováveis	Filipe Magalhães
2022	Dynamic Tests of two Laboratory Trays for the Santiago de Bernabéu Stadium Moveable Field	SENER	Elsa Caetano
2022	Monitoring of a Floating Wind Turbine	WIndPlus	Filipe Magalhães
2022	Development of mathematical algorithm for shape characterisation	STME	Elsa Caetano
2021-2022	Dynamic Testing of a Tuned Liquid Damper	Taylor Devices	Carlos Moutinho
2021-2024	Monitoring of the main nuilt heritage in the area of potential risks associated with the construction of the new circular line (pink) metro line	Metro do Porto	António Arêde
2020-2021	Technical support to Angola and Cabo Verde to integrate disaster risk and climate change considerations into school infrastructure investments	The World Bank	Xavier Romão
2018-2019	Technical analysis of the operational behaviour of Alfa Pendular train wheelsets	EMEF	Rui Calçada
2021	Survey of the built heritage in the area of potential risks associated with the construction of the new Casa da Musica - Santo Ovidio metro line	Metro do Porto	Nelson Vila Pouca
2019-2020	Methodology for the assessment of remaining lifespan of railway bridges	Infraestruturas de Portugal	Rui Calçada
2019-2020	Appraisal and definition of the repair solution for the hydraulic-powered structure in Santo Antão Island (Canal Bridge)	Infraestruturas de Cabo Verde e Instituto do Património Cultural de Cabo Verde	Nelson Vila Pouca
2020	Structural and geotechnical rehabilitation of Penedono Castle	Município de Penedono	António Arêde
2019	Prediction of vibrations induced by the passage of the Porto Light Rail vehicles near Line G and the extension of the Yellow Line	Metro do Porto	Pedro Costa

Relevant Consultancy Projects

Year	Project	Contracting entity	Principal Investigator
2016-2020	Structural monitoring of São Lourenço Church, Porto	Seminário Maior de Nossa Senhora da Conceição	António Arêde
2019	Evaluation of the possibility of introducing new vehicles with 12.5 t/axle on the Porto Light Rail Network	Metro do Porto	Rui Calçada
2018-2019	Advanced nonlinear modelling and performance assessment of masonry infills in RC buildings under seismic loads: the way forward to design or retrofit	Università degli Studi di Napoli Federico II	Humberto Varum
2017-2018	Research Collaboration under the project IN2TRACK	Railenium - Technological Research Institut	Rui Calçada
2021	Rehabilitation and reinforcement of a Ponte de Arame	Associação de Municípios do Baixo Tâmega	Nelson Vila Pouca
2020-2021	EU-ASEAN Dialogue Instrument (E-READI)	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Gmbh-Dag	Humberto Varum
2020-2021	Report on the intervention in Bolhão market gallery, Porto	Go Porto - Gestão e Obras do Porto	António Arêde
2018	Analysis of the roof collapse of the Porto Editora building's main structure	Fidelidade - Companhia de Seguros	António Arêde
2017-2020	Project Team for the Evolution of the Structural Eurocode CEN/TC 250 SC8.T2	Nederlands Normalisatie-instituut, Dept. Materials & Construction Products	Humberto Varum
2019	Metro do Porto - Evaluation of the building stock with potential risk associated with the deviation of the Vila River	Metro do Porto	Nelson Vila Pouca
2019	Offshore Structures Consultancy	FORCE Technology Norway	José Correia
2020	Evaluation of the load capacity and dynamic analysis of the roof of the Pasteleira Reservoir	Câmara Municipal do Porto	António Arêde
2019	Numerical Evaluation of the AASHTO IM-Dynamic Load Allowance Factor in Modular Bridges of the Peru-Provias Project - Deterministic Approach	BERD - Projecto, Investigação e Engenharia de Pontes	Rui Calçada
2016-2019	Experimental cyclic tests on full-scale reinforced concrete columns	University College of London	Humberto Varum

Relevant Consultancy Projects

Year	Project	Contracting entity	Principal Investigator
2021-2022	MULTI-Contrating Authority: EU Delegation to Indonesia and Brunel Damussalam	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Gmbh-Dag	Humberto Varum
2018	Dynamic analysis of high speed Railway tracks - Assessment of critical speed	MOTT MACDONALD LTD	Pedro Costa
2020-2022	Out-of-plane performance assessment of infill walls under tsunamic-induced loads	Università degli Studi di Napoli Federico II	Humberto Varum
2019	Numerical Evaluation of the AASHTO IM-Dynamic Load Allowance Factor in Modular Bridges of the Peru-Provias Project - Probabilistic Approach	BERD - Projecto, Investigação e Engenharia de Pontes	Rui Calçada
2019	Structural verification and analysis of a solution for the reinforcement of anchorages for 3 models of energy transmission poles	METALOGALVA	Rui Carneiro de Barros
2020	Fatigue assessment of Tocantins road and railway Bridge (Brazil) - Global and local approaches	Viaponte - Projecto e Consultoria de Engenharia	José Correia
2018	Structural verification of tubular supports for energy transmission lines (400kV) and their foundations	METALOGALVA	Rui Carneiro de Barros
2020	Special studies and tests in the scope of the rehabilitation of the old mining area of São Domingos - rehabilitation and strengthening of two large masonry chimneys: physical and chemical characterization of the original lime mortars, nonlinear pushover analysis prior and after the rehabiliation, ambient vibration tests.	Conduril, S.A.	Mário Pimentel
2019 - 2020	Inpection, safety assessment and continuous monitoring of the Koopman International Building	FISPOR, Serviços de Engenharia, Lda.	Mário Pimentel
2018 - 2019	Durability assessment of permanent lining of the levada Tunnel belonging to the Metro Porto network	LGC – Linha de Gondomar Construtores, ACE	Mário Pimentel
2018 - 2019	Structural assessment and rehabilitation of the São Vicente mining shaft trestle	Câmara Municipal de Gondomar	Mário Pimentel

Relevant Consultancy Projects
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Year	Project	Contracting entity	Principal Investigator
2020 - 2022	Monitoring of a windtower foundation in Serra d'El Rei windpharm	EDP-Renewables	Mário Pimentel
2018 - 2019	Engineering consultant services in the scope of Rogun Dam Project. Themo-mechanical analyses of the construction sequence of the concrete pad.	STUCKY, Ltd	Mário Pimentel
2018	Structural safety assessment and global stability analysis of the power intake structure of Nurek HPP	STUCKY, Ltd	Mário Pimentel
2019	Laboratory load tests on composite slabs for determination of the m-k parameters according to the EN1994-1. Design tables and design recomendations.	Rede Moderna, Lda	Mário Pimentel
2018 - 2019		Termopainel, S.A	
2017 - 2018	Laboratory load tests on modular bridge panels	BERD, S.A	Mário Pimentel
2020	Diagnostic load tests and safety assessment of building slabs.	Garcia, Garcia, S.A. - Design & Build	Mário Pimentel
2018		NEYA – Empreendimentos Hoteleiros e Turísticos, Lda.	
2023	MATCH — Application of the Match-App Tool to the Devesas' Area, Vila Nova de Gaia, Portugal	Gaiurb – Urbanismo e Habitação, E.M.	Cilísia Ornelas
2023	Structural and material characterization of the south wing of the National Museum of Archeology	Direção Geral do Património Cultural (DGPC)	António Arêde
2023	Technical assessment of the city hall building of Monforte	Monforte Municipality	Nelson Vila Pouca
2023	Structural survey of the São Bento railway station building and the Casa da Música subway station building – new subway line Troço Liberdade / S. Bento - Boavista / Casa da Música	Metro do Porto	Nelson Vila Pouca
2023	Structural survey of buildings in the area of influence of the new subway line Casa da Música - Santo Ovídio	Metro do Porto	Nelson Vila Pouca
2023	Architectural and structural documentation of the São Bento da Vitória Monastery in Porto	Teatro Nacional São João, E.P.E.	Nelson Vila Pouca

Relevant Consultancy Projects

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Year	Project	Contracting entity	Principal Investigator
2023	Structural survey of the Torre da Marca National Monument in Porto	Metro do Porto	Nelson Vila Pouca
2023	Technical support for the conservation works of the façades of the Portuguese Centre of Photography	Direção-Geral do Livro, dos Arquivos e das Bibliotecas (DGLAB)	Nelson Vila Pouca
2023	Development of Climate Change Adaptation and Disaster Risk Management Guidelines for UNESCO Designated Sites in Southeast Europe	UNESCO	Xavier Romão
2023	Technical support for the development of guidelines addressing the seismic strengthening of buildings	Lisbon Municipality	Xavier Romão
2022	Technical survey and assessment of the state of conservation and stability of decorative and sculptural elements of the façades of the São João National Theater	Teatro Nacional São João, E.P.E.	Nelson Vila Pouca
2022-2023	Conservation and restoration of the arches and columns of the transept of the old Carmo Church in Lisbon	Archeological Museum of Carmo	António Arêde
2022	Diagnosis of the concrete structure of the building of the old Lactogal factory	Icon, Sicafi, S.A.	Carlos Sousa
2022	Survey, tests and structural analysis for assessment of the ultimate strength of slabs, beams and columns, in an existing building belonging to "Clínica Madrialli", in Braga	Clínica Madrialli, Lda	Carlos Sousa
2022	Nonlinear finite element analysis, for assessment of serviceability and ultimate strength, in structural components belonging to a building located in Casalinho, Vila do Conde	Pedro Parreira (architect in charge of the building project)	Carlos Sousa
2021	Tests and analyses for characterization of material and structural parameters in building 5 belonging to the "Seminário do Bom Pastor", in Ermesinde	Diocese do Porto	Carlos Sousa
2021	Study on the pathologies observed in the filtered water reservoir of the Lever Water Treatment Plant	Águas do Douro e Paiva, S.A.	Carlos Sousa
2021	Inspection and characterization tests of the reinforced concrete roof slab	Águas do Douro e Paiva, S.A.	Carlos Sousa

Year	Project	Contracting entity	Principal Investigator
	and beams covering the South Cell of the Jovim Reservoir		
2021	Survey, tests and analyses to determine the load capacity of a floor in the industrial facilities of Sodecia Powertrain Guarda S.A.	Sodecia Powertrain Guarda S.A.	Carlos Sousa
2020 - 2022	Survey and laboratorial tests for assessment of the structural condition of a water reservoir, built in the 1940s, with signs of deterioration due to reinforcement corrosion.	Águas do Douro e Paiva, S.A.	Carlos Sousa
2020 - 2022	Survey and tests for assessment of mechanical properties and properties affecting the durability, in structural concrete members, in an industrial facility with a total area of 15000m2	Pemel - Omatapalo Group	Carlos Sousa
2019 - 2022	Periodic inspections to the reinforced concrete columns of a water reservoir undergoing deterioration due to alkali-silica reaction. Assessment of the structure condition.	Águas do Douro e Paiva, S.A.	Carlos Sousa
2018 - 2019	Assessment of the ultimate capacity and structural behaviour in service, for an industrial building structure changing occupancy, for installation of an automated storage and retrieval system. Definition of strengthening alternatives.	Cooprofar-Medlog	Carlos Sousa
2019	Survey and laboratorial testing for assessment of concrete properties in an industrial building structure built in the 1970s (with roof structure composed by thin precast prestressed hyperbolicparabolic shells with a maximum span of 20m), showing signs of material deterioration.	Civi4 Lda	Carlos Sousa
2018	Diagnosis and Development of Rehabilitation Solutions for the pavements of the Port of Leixões. 1st phase: Preliminary diagnosis and proposal for development.	APDL - Administração dos Portos do Douro, Leixões e Viana do Castelo	António Viana da Fonseca

Relevant Consultancy Projects

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Year	Project	Contracting entity	Principal Investigator
2018	Curriculum evaluation of the candidates to be part of the designer grants for the rehabilitation of buildings from the National Fund for Building Rehabilitation (FNRE)	FUNDIESTAMO - Sociedade Gestora de Organismos de Investimento Coletivo, S. A.	António Viana da Fonseca
2019 - 2020	Safety assessment and study of risk mitigation measures for safeguarding mining tailings dams in the State of Minas Gerais, Brazil	Ministério Público de Mingas Gerais da Repúbica Federal do Brasil	António Viana da Fonseca
2019 - 2021	Determination of the probable and/or determining and/or simultaneous causes of the collapse of the B1 dam at the Córrego de Feijão Mine in Brumadinho, Minas Gerais	VALE, SA, Agreement with the Federal Public Prosecutor's Office in MG, Brazil	António Viana da Fonseca (PI at FEUP)
2021 - 2022	Complementary analyzes on the results of advanced geomechanical tests on new samples collected on site from the B1 dam basin in Brumadinho, post-mortem	Centro Internacional de Métodos Numéricos en Ingeniería (CIMNE), General. e Univ. Polit. Catalunya	António Viana da Fonseca
2021 - 2022	Specialized Technical Appraisal of the Execution Project for the Drainage Tunnels of the City of Lisbon and Associated Interventions - 23 execution projects for the construction of 2 Drainage Tunnels	Câmara Municipal de Lisboa - Empresa Pública do Plano Geral de Drenagem de Lisboa	António Viana da Fonseca, António Topa Gomes
2018 - 2021	Environmental monitoring of Eastern Algarve landfill	Câmara Municipal de Loulé	Maria Lurdes Lopes
2018	Vale do Lima and Baixo Cávado Landfill	Resulima	Maria Lurdes Lopes
2017 - 2018	Assessment of the potential of waste incineration bottom ashes as precursor material in alkaline reactions	LIPOR	Maria Lurdes Lopes
2017 - 2018	Evaluation and test of construction ink applicators	PARDAL, fábrica de Pincelaria	Maria Lurdes Lopes
2020	Celorico de Basto Landfill	Resinorte	Maria Lurdes Lopes
2021 - 2022	Inspection, diagnostic study and intervention methodology of the Neo-Gothic greenhouse located in "Parque da Lavandeira in Vila Nova de Gaia"	Câmara Municipal de Vila Nova de Gaia	Vasco Peixoto de Freitas

Relevant Consultancy Projects

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Year	Project	Contracting entity	Principal Investigator
2021 - 2022	Conservation and Maintenance Plan for the Main Building of the Faculty of Economics of the University of Porto	Universidade do Porto	Vasco Peixoto de Freitas/Rui Calejo
2021 - 2022	Diagnostic study and intervention methodology of the Building of the Judicial Court of Seia	Instituto de Gestão Financeira e Equipamentos da Justiça, I. P.	Vasco Peixoto de Freitas
2022	3D scanning and BIM modelling of the Alfândega tunnel	Empresa de águas e energia do município do Porto, EM	Nuno Ramos João Poças Martins
2022 - 2024	Civil technical consultancy for the project and execution of the new installations of fusevalley Farfetch	Farfetch Portugal - Unipessoal, Lda.	Hipólito de Sousa
2018 - 2022	Elaboration and development of a strategic plan for the rehabilitation and maintenance of the municipal housing stock in Matosinhos (1st and 2nd phases)	MatosinhosHabit-MH, Empresa Municipal Habitação	Hipólito de Sousa
2019 - 2020	Technical consultancy on the suitability of an external stone cladding for a Building	Banco BPI, S.A.	Hipólito de Sousa
2021 - 2022	Digital building materials (MC digital)	APCMC	Hipólito de Sousa
2018 - 2020	Study and implementation of restructured contents in contractual documents/Technical Specifications and Elaboration of a Manual of Project and Execution procedures	CMPEA - Empresa de Águas do Município do Porto, EM	Hipólito de Sousa
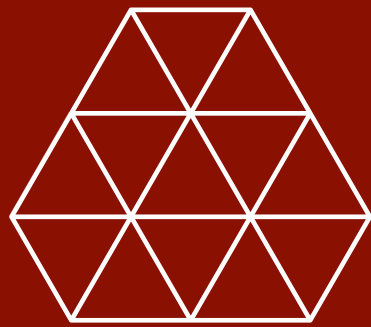
PhD THESES

Year	Project	Author	Supervisor /Co-supervisor	Institution
2018	Sustentabilidade das habitações de Interesse Social nas Cidades de João Pessoa, Recife e São Paulo: Avaliação das Práticas e Proposta de Melhorias	Elisabeth Maria Ferreira Severo	Hipólito Sousa	Faculade de Engenharia da Universidade do Porto
2018	Metodologia para definição da estratégia de implementação do BIM	António Machado Ruivo Sanguêdo Meireles	Hipólito Sousa	Faculade de Engenharia da Universidade do Porto
2018	Análise Termo-Higro-Mecânica das Tensões Autoinduzidas em Estruturas de Betão	Luís Pedro Pinto Leitão	Rui Manuel Carvalho Marques de Faria /Miguel Ângelo Dias Azenha (UMinho)	Faculade de Engenharia da Universidade do Porto
2018	Dynamic behaviour and fatigue assessment of Railway Bridge deck slabs	Joel Pedro da Conceição Malveiro	Rui Calçada/Carlos Sousa	Faculade de Engenharia da Universidade do Porto
2018	Maintenance support strategies for reinforced concrete structures under corrosion risk	Pablo Daniel Benítez Mongelós	Maria Fernanda Rodrigues Humberto Varum	Universidade de Aveiro
2018	Seismic Performance Assessment and Strengthening Techniques for Existing Reinforced Concrete Buildings in Nepal	Rakesh Dumaru	Humberto Varum /Hugo Rodrigues	Faculade de Engenharia da Universidade do Porto
2018	Seismic Safety and Risk Assessment of Existing Steel Buildings	Miguel Neves Martins Ferreira de Araújo	José Miguel Castro	Faculade de Engenharia da Universidade do Porto
2018	Performance-Based Seismic Design and Assessment of Steel Moment Frame Buildings	Luís Augusto Ferreira Rodrigues de Macedo	José Miguel Castro/Rui Faria	Faculade de Engenharia da Universidade do Porto
2018	Dynamic behaviour and fatigue assessment of railway bridge deck slabs	Joel Pedro da Conceição Malveiro	Rui Calçada/Carlos Sousa	Faculade de Engenharia da Universidade do Porto
2018	Seismic Assessment of Composite Frames with Concrete-Filled Steel Tube Columns	Yadong Jiang	Ricardo Monteiro/José Miguel Castro	Scuola Universitaria Superiore IUSS Pavia
2018	Avaliação do Comportamento dos Ocupantes no Desempenho Higrotérmico em Edifícios Residenciais Visualizar Publicação	Fernando Pedro Fernandes Pereira	Nuno Manuel Monteiro Ramos	Faculade de Engenharia da Universidade do Porto

PhD Theses

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Year	Project	Author	Supervisor /Co-supervisor	Institution
2018	Efeitos do vento em estruturas de cabos e membranas tensas	Pedro Gil Marques de Queirós Ferreira	Elsa Caetano	Faculade de Engenharia da Universidade do Porto
2018	Efeito da Interação Humana em Pisos de Edificações Submetidos a Atividades Humanas Rítmicas	Cássio Gaspar	José Guilherme Santos da Silva/ Elsa Caetano	Universidade Estadual do Rio de Janeiro
2018	Earthquake Damage and Loss Assessment of Reinforced Concrete Buildings	Luís Carlos Ribeiro Martins	Rdelgado/Mário Marques e Vítor Silva	Faculade de Engenharia da Universidade do Porto
2018	Atualização do modelo numérico de ponte estaiada baseado em dados experimentais	Iviane da Cunha Santos	José Luís Vital de Brito/Elsa Caetano e Dan Mircea Frangopol	Universidade de Brasília
2018	Modelling the Long Term Cyclic Behaviour of Porto Silty-Sand Stabilised with Cement	António Fabrizio Panico	António Viana da Fonseca/Jean Vaunat	Faculade de Engenharia da Universidade do Porto
2019	Previsão e mitigação de vibrações e ruído estrutural induzidos por tráfego ferroviário	Aires Manuel Silva Colaço	Pedro Miguel Barbosa Alves Costa/ Rui Calçada e Paulo Amado-Mendes	Faculade de Engenharia da Universidade do Porto
2019	La Sobrerresistência En Puentes Mexicanos de Concreto Reforzado	Alma Rosa Sánchez Ibarra	António José Coelho Dias Arêde/ José Manuel Jara Guerrero e Pedro da Silva Delgado	Faculade de Engenharia da Universidade do Porto
2019	Assessing the seismic performance of existing reinforced concrete buildings: from standard-based methods to full probabilistic approaches	Nuno Manuel da Silva Pereira	Xavier das Neves Romão	Faculade de Engenharia da Universidade do Porto
2019	Caracterização de alvenarias de granito baseada em técnicas geofísicas, mecânicas e redes neuronais	Rachel Jardim Martini Santos	António José Coelho Dias Arêde e José Manuel Jara Guerrero e Pedro da Silva Delgado/Humberto Salazar Amorim Varum e Jorge Manuel Cabral Machado de Carvalho	Faculade de Engenharia da Universidade do Porto
2019	Modelação Numérica do Comportamento Não Linear do Betão Armado nas Estruturas de Suporte de Escavações Urbanas	JOSÉ CÂNDIDO GONÇALVES FREITAS	Manuel António de Matos Fernandes/Miguel Ângelo Carvalho Ferraz e Carlos Félix	Faculade de Engenharia da Universidade do Porto

PhD Theses

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Year	Project	Author	Supervisor /Co-supervisor	Institution
2019	Smart Structural Health Monitoring Applied to the Management and Conservation of Bridges	EMANUEL RODRIGUES DE SOUSA TOMÉ	Mário Jorge de Seixas Pimentel/ Joaquim de Azevedo Figueiras	Faculade de Engenharia da Universidade do Porto
2019	Advanced Methodology for the Estimation of Economic Seismic Losses in RC Buildings	TUBA TATAR	Mário Marques/Mário Jorge de Seixas Pimentel; José Miguel de Freitas Castro	Faculade de Engenharia da Universidade do Porto
2019	Geomecânica de um Agregado Siderúrgico Inerte como Material Alternativo para Lastro de Vias Férreas do Tipo Heavy Hau	Bruno Guimarães Delgado	António Joaquim Pereira Viana da Fonseca/Eduardo Manuel Cabrita Fortunato	Faculade de Engenharia da Universidade do Porto
2019	Structural Condition Assessment of Dams based on Continuous Dynamic Monitoring	Sérgio Bouça Pereira	Filipe Magalhães/Álvaro Cunha	Faculade de Engenharia da Universidade do Porto
2019	Interface influence on moisture transport in building components	António Augusto Costa de Azevedo	Ana Sofia Guimarães/Vasco Peixoto de Freitas	Faculade de Engenharia da Universidade do Porto
2019	Indoor climate management on cultural heritage buildings: Climate control strategies, cultural heritage management and hygrothermal rehabilitation	Hugo Filipe Entradas Silva	Fernando Henriques/Vasco Peixoto de Freitas	Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa
2019	Durabilidade de Rebocos Térmicos	Joana Fernandes Maia	Nuno Manuel Monteiro Ramos/ Maria do Rosário Veiga	Faculade de Engenharia da Universidade do Porto
2020	Performance-based seismic analysis of reinforced concrete buildings accounting for the angle of seismic incidence	Despoina Skoulidou	Xavier Romão	Faculade de Engenharia da Universidade do Porto
2020	A framework to assess disaster resilience based on the sustainable development goals	Carlotta Rodriquez	Ricardo Monteiro (IUSS)/Mario Martina (IUSS), Xavier Romão e José Manuel Oliveira Mendes (FE-UC)	Instituto Universitario di Studi Superiori di Pavia
2020	Seismic vulnerability assessment and retrofitting strategies for masonry infilled frame buildings considering in-plane and out-of-plane behaviour	André Filipe Castanheira Alves Furtado	António Arêde/Hugo Filipe Pinheiro Rodrigues-IPL	Faculade de Engenharia da Universidade do Porto

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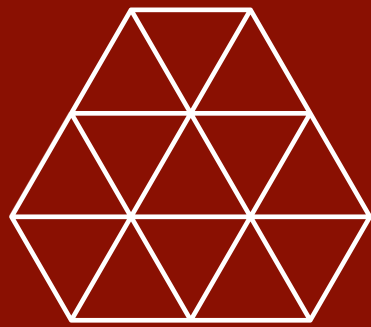| Year	Project	Author	Supervisor /Co-supervisor	Institution
2020	Mechanical characterization of stone masonry walls of Porto region: experimental and numerical contributions	Rui Manuel Soares Ferreira da Silva	António Arede/Celeste Almeida e Patrício Almeida Rocha	Faculade de Engenharia da Universidade do Porto
2020	Influência da Disposição das Juntas de Contração em Barragens Abóbada de Betão	José João Guedes Morais da Conceição	Rui Faria/Miguel Azenha UMinho) e Manuel Pinho de Miranda	Faculade de Engenharia da Universidade do Porto
2020	Computer vision and machine learning appraoches for modal analysis and damage detection	Moisés da Silva	João Weyl da Costa (Universidade Federal do Pará, Brasil)/Elói Figueiredo	Instituto Universitario di Studi Superiori di Pavia
2020	Design of eco-efficient ultra-high performance fibre reinforced cement-based composite for rehabilitation/strengthening applications"	Ana Mafalda Matos	Sandra Nunes/José Luís Barroso Aguiar (UMinho)	Faculade de Engenharia da Universidade do Porto
2020	Comportement des sols traitées à la chaux à long term. Docteur en Génie Civil Spécialité Géomateriaux	Nabil Maafi	Akchiche Mustapha/Sara Rios	Université des Sciences et de la Technologie Houari Boumedienne, Argel
2020	Comparação do índice de desconforto passivo com a classe energética de edifícios de habitação reabilitados do sul da europa	Sílvia Alexandra de Magalhães Barbosa	Vasco freitas/José Luís Alexandre	Faculade de Engenharia da Universidade do Porto
2020	School Building Rehabilitation in Southern European Climate Combining Comfort and Low Energy Consumption	Maria Francisca Lima Carneiro Cavaleiro Barbosa	Vasco freitas/José Luís Alexandre	Faculade de Engenharia da Universidade do Porto
2021	Strengthening of Reinforced Concrete Elements with UHPFRC	Aurélio Guilherme Sine	Mário Pimentel/Sandra Nunes e Américo Ocua Dimande	Faculade de Engenharia da Universidade do Porto
2021	Artificial Intelligence for an Enhanced As-Is BIM Energy AnalysisSubtítulo: Enabling an efficient energy retrofit through the automation of the scan-to-BIM process	Luís Pedro Neves Sanhudo	João Poças Martins/Nuno Ramos	Faculade de Engenharia da Universidade do Porto
2021	MODELAÇÃO NUMÉRICA DA INSTABILIDADE LATERAL DE VIAS-FÉRREAS	David Alexandre de Brito Pereira	José Couto Marques/Rui Calçada	Faculade de Engenharia da Universidade do Porto
2021	Damage identification in railway bridges based on train induced dynamic responses	Andreia Gomes Meixedo	Rui Calçada/Diogo Ribeiro e João Pedro Santos	Faculade de Engenharia da Universidade do Porto

PhD Theses
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Year	Project	Author	Supervisor /Co-supervisor	Institution
2021	Durabilidade das alvenarias de blocos de gesso – limites de sua utilização	Carlos Welligton de Azevedo Pires Sobrinho	Nuno Ramos/Yêda Vieira Póvoas Tavares (Brasil) e Vitor Abrantes	Faculade de Engenharia da Universidade do Porto
2021	Cyclic Liquefaction Susceptibility of Soils from Field and Laboratory Tests. Methodologies and critical analyses	Catarina Paisana Ferreira Correia Ramos	António Viana da Fonseca/ Matthew Richard Coop da University College London	Faculade de Engenharia da Universidade do Porto
2021	Integrated Methodologies for Fatigue Life Predictions of Existing Metallic Railway Bridges	Cláudio Carlos da Silva Horas	Rui Calçada/Abílio Jesus (FEUP)	Faculade de Engenharia da Universidade do Porto
2021	Aterros sobre solos moles reforçados com colunas de brita. Análise numérica e experimental	Daniela Alexandra Oliveira Marques	José Leitão Borges/António Viana da Fonseca	Faculade de Engenharia da Universidade do Porto
2021	ELECTRONIC PRODUCTIVITY PERFORMANCE MONITORING OF CONSTRUCTION WORKERS	Diego Calvetti Ney	Migule Chichorro Gonçalves/Vitor Abrantes e Hipólito Sousa	Faculade de Engenharia da Universidade do Porto
2021	Structural stress-based methodologies for fatigue assessment of welded railway bridges	Guilherme Santana Alencar	Rui Calçada/ Abílio Jesus (FEUP) e José Guilherme Santos da Silva (UERJ)	Faculade de Engenharia da Universidade do Porto
2021	A influência das ações sísmicas nas edificações brasileiras em concreto armado	Paulo de Souza Tavares Miranda	Humberto Varum/Nelson Vila Pouca	Faculade de Engenharia da Universidade do Porto
2021	Desenvolvimento de um sistema de informação para o controlo da conformidade em obra. Modelo de dados para aplicação web	Rui Micael Silva Bessa	Rui Calejo	Faculade de Engenharia da Universidade do Porto
2021	Avaliação de patrimônios históricos em estruturas de concreto armado: Proposta de formulação acoplada entre integridade e segurança	Ana Luiza Alves de Oliveira	João da Costa Pantoja/Humberto Varum	Universidade de Brasília
2021	Modelling of The Fatigue Crack Initiation and Propagation Behaviour in Metals and Alloys	Victor Hugo Ribeiro	Aparecido Gonçalves/José A.F.O. Correia	Universidade Estadual Paulina
2021	Risk-based Bailway Infrastructure Management Systems	João Nuno Duarte Fernandes	José António Campos e Matos (UMinho), Daniel Vitorino de Castro Oliveira (UMinho), António Abel Ribeiro Henriques	Universidade do Minho

PhD Theses
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Year	Project	Author	Supervisor /Co-supervisor	Institution
2021	Metodologia Para Gestão de Riscos Geológico-Geotécnicos em Áreas Urbanas: os casos do concelho do Porto e Contagem, MG	Luciene Oliveira Menezes	Maria Giovana Parizzi (UFMG, Brasil)/ António Viana da Fonseca	Universidade Federal de Minas Gerais / Faculdade de Engenharia da Universidade do Porto
2021	Indoor Thermal Comfort and Energy Performance of Residential Light Steel Framing Buildings	Eduardo José Escaroupa Roque	Romeu Vicente (Universidade de Aveiro)/Almeida, R.M.S.F	Universidade de Aveiro
2022	Gestão de Edifícios - Intervenções em edifícios considerando o conceito de fruição das instalações	Jorge Manuel Faísca Renda	Rui Calejo	Faculade de Engenharia da Universidade do Porto
2022	Seismic risk reduction of reinforced concrete buildings retrofitted with steel braces	Rodrigo Esmeriz Falcão Moreira	José Miguel de Freitas Castro/ Humberto Varum e Mário Marques	Faculade de Engenharia da Universidade do Porto
2022	Influência de novas soluções de alvenaria de enchimento no dimensionamento de edifícios porticados de betão armado	Marta Alexandra Baptista Agante	Humberto Varum/Hugo Filipe Pinheiro Rodrigues (UA) e Paulo Alexandre Lopes Fernandes (IPL)	Faculade de Engenharia da Universidade do Porto
2022	Advanced non-linear numerical simulation tools for in-service and retrofitting assessment of stone masonry railway arch bridges - Experimental calibration and validation	Rúben Filipe Pereira da Silva	António Arêde/Cristina Margarida Rodrigues Costa (IPT)e Daniel Vitorino de Castro Oliveira (UM)	Faculade de Engenharia da Universidade do Porto
2022	Enhanced fatigue and seismic performance of metallic structures retrofitted with CFRP	Anis Issam Mohabeddine	José Correia/José Miguel Castro	Faculade de Engenharia da Universidade do Porto
2022	Modelação numérica de sistemas periódicos: avaliação do comportamento dinâmico de vias férreas e medidas de mitigação de vibrações	Alexandre Manuel Gonçalves Castanheira Pinto	Pedro Alves Costa/Luis Godinho	Faculade de Engenharia da Universidade do Porto
2022	Estabilização de solo sedimentar contaminado através de cimentos alcalinos aplicados com recurso à técnica de Deep Soil Mixing	Claver Giovanni da Silveira Pinheiro	António Viana da Fonseca/Sara Rios Silva	Faculade de Engenharia da Universidade do Porto
2022	Effect of Viscoelastic Damping of Polymer-based Composite Materials in the Mitigation of Footbridge Vibrations	Vítor Dacol	Elsa caetano/João Ramôa Correia	Faculade de Engenharia da Universidade do Porto

PhD Theses
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Year	Project	Author	Supervisor /Co-supervisor	Institution
2022	Development of New Methodologies for Structural Health Monitoring of Wind Farms	João Miguel de Sousa Pacheco	Filipe Magalhães/ Álvaro Cunha	Faculade de Engenharia da Universidade do Porto
2022	Airtightness Contribution for a Sustainable Building Stock in the Context of Southern Europe	Vitor Emanuel Martins Cardoso	Nuno Ramos/Maria Manuela Almeida (UM)	Faculade de Engenharia da Universidade do Porto
2022	Influence of moisture and relative humidity in the energy consumption of retrofitted walls	Olivia Mafalda Afonso Amorim Rocha	Vasco P. de Freitas/ Isabel Torres	Faculade de Engenharia da Universidade do Porto
2022	Thermal insulation solution for historic buildings: feasibility, efficacy, compatibility	Magda Posani	Maria do Rosário Veiga (LNEC)/Vasco Peixoto de Freitas	Faculade de Engenharia da Universidade do Porto
2022	Influence of chained masonry on the behavior of reinforced concrete buildings under seismic loading	Abdelkader Nour	Abdelkader Benanane/Humberto Varum	Universite Abdelhamid ibn Badis Mostaganem
2022	Vulnérabilité et réhabilitation sismique des anciennes mosquées de la ville de Chlef	Yassine Zelmat	Mohammed El-Amine Sidi Bourdim/ Humberto Varum	Universite Abdelhamid ibn Badis Mostaganem
2023	Monitorizaçao estrutural de cimbres autolançáveis	André Filipe de Bastos Resende	Pedro Pacheco/Filipe Magalhães	Faculade de Engenharia da Universidade do Porto
2023	Development and validation of bimbased natural user interfaces for non-geometrical information management	Fábio Alexandre Matoseiro Dinis	João Poças Martins/Bárbara Rangel e Ana Sofia Guimarães	Faculade de Engenharia da Universidade do Porto
2023	Diretrizes bioclimáticas de apoio ao projeto para otimização do desempenho térmico de habitações económicas em adobe no Ceará-Brasil	Levi Teixeira Pinheiro	Bárbara Rangel/Ana Sofia Guimarães e Humberto Varum	Faculade de Engenharia da Universidade do Porto
2023	Identification and analysis of contributing factors related to road crashes	Mariane Paula Bobermin	Sara Ferreira	Faculade de Engenharia da Universidade do Porto
2023	Avaliação do impacto de técnicas de arrefecimento passivo no conforto térmico interior de edifícios em climas quentes e húmidos	Murilo de Pádua Marcolini	Eva Barreira/Ricardo Almeida (IPV)	Faculade de Engenharia da Universidade do Porto

RELEVANT
SCIENTIFIC
MEETINGS

Relevant Scientific Meetings

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Year	Scientific Event	Local	Website
2018	9th European Conference on Numerical Methods in Geotechnical Engineering, NUMGE 2018	Porto, Portugal	https://numge2018.pt/
	Construção 2018 – Reabilitar e construir de forma sustentável	Porto, Portugal	https://web.fe.up.pt/~construcao2018/
	International Conference on Diffusion in Solids and Liquids, DSL-2018	Amsterdam, Netherlands	
	SynerCrete'18 – First International Conference on Interdisciplinary Approaches for Cement-Based Materials and Structural Concrete	Funchal, Portugal	https://synercrete.com/
	2nd Portuguese Congress on Building Information Modelling, PTBIM	Lisboa, Portugal	
	First International Symposium on Risk Analysis and Safety of Complex Structures and Components, IRAS 2019	Porto, Portugal	https://paginas.fe.up.pt/~iras2019/
2019	9th International Conference on Arch Bridges, ARCH 2019	Porto, Portugal	https://paginas.fe.up.pt/~arch19/
	New education technologies for online teaching	Porto, Portugal	
	GESCON18/19	Porto, Portugal	
	10th AECEF Symposium	Wroclaw, Poland	http://aecef2019.pwr.edu.pl/
	15th International Conference on Diffusion in Solids and Liquids, DSL-2019	Athens, Greece	
2020	2º Congresso de Ensaios e Experimentação em Engenharia Civil, TEST&E 2019	Porto, Portugal	https://www2.isep.ipp.pt/teste2019/
	Virtual Conference on Mechanical Fatigue, VCMF	Porto, Portugal	
	16th International Conference on Structural Repair and Rehabilitation, CINPAR 2020	Porto, Portugal	https://haengenharia.pt/vai-acontecer/cinpar-2020-xvi-international-conference-on-structural-repair-and-rehabilitation/
	14th International Conference on Automatic Control and Soft-Computing	Bragança, Portugal	https://controlo2020.ipb.pt/

| Year	Scientific Event	Local	Website
2021	17th International Conference on Diffusion in Solids and Liquids, DSL-2021	Malta	
	Congresso Nacional Reabilitar & Betão Estrutural 2020	Lisbon, Portugal	https://reabilitar-be2020.pt/
	2021 Fib Symposium "Concrete Structures: New Trends for Eco-Efficiency and Performance	Lisbon, Portugal	https://www.fib-international.org/events/fib-events/39-fib-2021-symposium.html
	Webinar i3Dc: S10 - Know your building: the non-intrusive part of structural inspection	Porto. Portugal	https://web.fe.up.pt/~i3dc/session-s10/
	Webinar i3Dc: S9 - From Matter to Shape: 3D Printing Precast Industry	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s9/
	Webinar i3Dc: S8 - From the shapeless earth to the earth as house-shaped	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s8/
	Webinar i3Dc: S7 - Rapid Construction Using Traditional Capabilities and Compatibility with New Materials	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s7/
	Webinar i3Dc: S6 - 3D printing: Challenges and Opportunities in Construction	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s6/
	Webinar i3Dc: S5 - Resource-efficient construction of steel structures using laser cutting and metal 3D printing	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s5/
	Webinar i3Dc: S4 - Advances and Collaboration across the Architecture, Engineering, and Construction Industries: 2021 and Beyond	Porto, Portugal	https://web.fe.up.pt/~i3dc/session-s4/
	1st Joint EUCEET AECEF Conference - The role of education for civil engineers in the implementation of the SDGS	Thessaloniki, Greece	https://websites.auth.gr/euceetaecef2021/
	10th International Conference on Structural Health Monitoring of Intelligent Infrastructure, SHMII-10	Porto, Portugal	https://web.fe.up.pt/~shmii10/
	17th International Conference on Building Pathology and Constructions Repair, CINPAR 2021	Fortaleza, Brasil	

Year	Scientific Event	Local	Website
	International Congress on Structural Integrity and Maintenance, SIM 2021	Belo Horizonte, Brasil	https://sim2021.eng.ufmg.br/
	7th International Conference on Crack Paths, CP2021	Rome, Italy	http://www.crackpaths.org/
	XX International Colloquium Mechanical Fatigue of Metals, ICMFM20	Wroclaw, Poland	https://icmfmxx.pwr.edu.pl/
	4th Doctoral Congress in Engineering (DCE21) - Civil Engineering and Spacial Planning	Porto, Portugal	
	XII Congresso Brasileiro de Pontes de Estruturas, XII CBPE 2021 (online)		
	1º Simpósio em Engenharia Civil	Porto, Portugal	
	17th EAWE PhD Seminar on Wind Energy	Porto, Portugal	https://phd2021.eawe.eu/
2022	Construção 2022	Guimarães, Portugal	https://civil.uminho.pt/construcao2022/
	IMEKO TC1-TC7-TC13-TC18 Symposium 2022: Cutting-edge measurement science for the future	Porto, Portugal	https://www2.isep.ipp.pt/imekotc7-mathmet-2022/
	MATHMET satellite workshop	Porto, Portugal	https://www2.isep.ipp.pt/imekotc7-mathmet-2022/
	18th International Conference on Diffusion in Solids and Liquids, DSL-2022	Florence, Italy	https://xantec.com.sg/ironix/dsl/2022/
	6as Jornadas Portuguesas de Engenharia de Estruturas	Lisbon, Portugal	http://jpee2022.lnec.pt/
	16th century church, Tx ReUSO Edition – International Conference on Documentation, Restoration and Reuse of Heritage	Porto, Portugal	https://paginas.fe.up.pt/~reuso/home/
	3º Congresso de Ensaios e Experimentação em Engenharia Civil, TEST&E 2022	Porto, Portugal	https://sites.google.com/fct.unl.pt/teste2022
	XI Congresso Luso Brasileiro de Geotecnia	Campinas, Brasil	https://cobramseg2022.com.br/xi-clbg/

Relevant Scientific Meetings

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Year	Scientific Event	Local	Website
2023	7ª conferência PATORREB (Patologia e Reabilitação de Edifícios)	Porto, Portugal	https://fe.up.pt/patorreb2023/
	19th International Conference on Diffusion in Solids and Liquids (DSL-2023)	Crete, Greece	https://ironix-conferences.com/dsl-2023/
	Webinar "Infrared Thermography for Building Pathology Inspection"	*online*	https://www.mdpi.com/about/announcements/6241
	2nd Workshop of Circular2B Project	Vila Real, Portugal	https://paginas.fe.up.pt/~circular2b/blog/2023/02/02/1986/
	Final Workshop of Circular2B project	Porto, Portugal	https://paginas.fe.up.pt/~circular2b/blog/2023/06/21/2003/
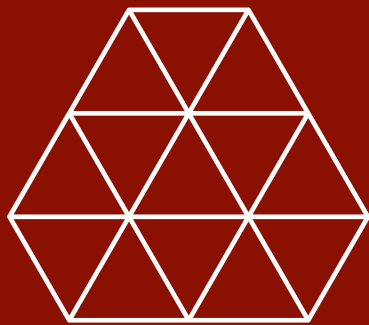
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and Construction
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