IMPACT

ADDRESSING THE NEEDS OF BRIDGES AND WIND TURBINES

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodwska-Curie grant agreement no. 676139

http://infrastar.eu

Impact Objectives

- Develop knowledge, expertise and skills for optimal and reliable management of structures such as bridges and wind turbines in relation to fatigue
- Provide early stage researchers with multidisciplinary training in both structural engineering and non-destructive testing monitoring and reliability

Addressing the needs of bridges and wind turbines

***Dr Odile Abraham** talks about the gaps in structural engineering training and the important role the **INFRASTAR** project plays in securing Europe's future in this diverse field*

Could you outline the specific aims of Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk (INFRASTAR) Project?

INFRASTAR aims to develop knowledge, expertise and skills for optimal and reliable management of structures. The generic methodology is applied to bridges and wind turbines in relation to fatigue, offering the opportunity to deal with complementary notions, (such as old and new asset management, unique and similar structures, and wind and traffic actions) while addressing three major challenges: 1) advanced modelling of concrete fatigue behaviour; 2) new non-destructive testing (NDT) methods for early aged damage detection; and 3) probabilistic approach of structure reliability under fatigue. INFRASTAR will improve knowledge for optimising the design of new structures, more realistic verification of structural safety, and more accurate prediction of the future lifetime of the existing structures.

What are the circumstances that have made the INFRASTAR project necessary?

A series of limitations currently hamper innovative solutions in the asset management of civil infrastructures. One of the most prevalent issues, which directly influences the life expectancy of concrete structures, is fatigue. Although fatigue has been investigated for years for steel structures, recent findings suggest that concrete structures are also significantly subjected to fatigue, which could lead to premature failure. A second issue relates to the current technological means to measure fatigue on civil structures like bridges and wind turbines, as these are outdated, imprecise and inappropriate. Finally, while structural reliability methods have been widely applied in some industrial applications (e.g. for offshore oil and gas structures, bridges exposed to fatigue, and wind turbines), practical application of probabilistic methods still needs theoretical and practical developments.

> *INFRASTAR fills a gap in training in Europe, where it is very difficult to find researchers in this particular field*

Will INFRASTAR help address the current deficit in European researchers with the skills necessary to the bridge and wind turbine field?

INFRASTAR fills a gap in training in Europe, where it is very difficult to find researchers in this particular field, with knowledge in both structural engineering and NDT monitoring and reliability. In this respect, young scientists referred to as early stage researchers (ESRs) will be excellent candidates at the end of the project. Such highly skilled researchers and engineers are clearly needed in such a multidisciplinary field. The European Wind Energy Technology Platform has stated that the career potential of the offshore wind industry has not yet been fully appreciated and the industry is on the cusp of becoming fully commercial, but the necessary engineers, technicians and programmes for development are currently unavailable.

How does the Marie Skłodowska-Curie Innovative Training Network (ITN) programme help to achieve the project's aims?

The Marie Skłodowska-Curie ITN programme enables INFRASTAR to benefit from cross-experience and interdisciplinary synergies that create new knowledge. The network partners provide the ESRs with a system-wide understanding of structure management on bridges and wind energy technology. This outstanding research training offer includes knowledge in materials to design loads, design of structures, monitoring of existing structures, development of sensors and innovative calculation methods for structural analysis, and optimal and reliable management of structures. The ESRs are acquiring a complete expertise in the field of optimal asset management and operation, with genuine opportunities of transfer to other domains in the academic/non-academic sectors such as the aeronautic, the nuclear or the naval industry. This programme will fill a gap in training in Europe, and ensure that the ESRs we employ will be excellent candidates at the end of the project.

New approaches to structural engineering and training

***Dr Ernst Niederleithinger**, **Professor Eugen Brühwiler** and **Professor John Dalsgaard Sørensen** discuss the different **INFRASTAR** work packages, visions for the future of the engineering field, and Europe's current infrastructure challenges*

Dr Ernst Niederleithinger, Professor Eugen Brühwiler and Professor John Dalsgaard Sørensen

What are the aims of your respective work packages (WPs) and what do they involve?

EN: WP1 deals with the measurement technology part of INFRASTAR. We have two PhD students working on sensing technologies (ultrasonic and fibre-optic), a third working on the sensitivity of techniques to detect fatigue, and a fourth connecting the innovative and conventional sensing techniques to a practical working system. All these topics are closely tied, so my first duty as a WP leader was to get them connected and to enable them to work on shared objects. Fortunately, Innovative Training Network (ITN) projects include joint trainings and secondments at each other's institutions. This helps a lot to get things up and running. We have a facility here at the Federal Institute for Materials Research and Testing (BAM), Germany, that allows joint experiments with lots of sensing technologies at an almost full-scale bridge model. Three of the four WP1 students have already worked here and the last one has just started.

EB: In WP2 our aim is to precisely analyse the behaviour of structural elements in wind turbines and bridges by means of continuous measurements, in order to establish realistic models for fatigue and extreme loading. We want to develop novel engineering methods to determine the fatigue life of relevant structural elements, such as bridge deck slabs or gravity base foundations of wind turbines. To achieve this aim, research interlinked in four different but related domains is being undertaken by four PhD students.

JDS: Leading WP3 requires coordinating activities on a more general level, contributing to the organisation of training weeks, and preparing input for dissemination of the general results produced by the ESRs. Our research aims are to apply the theoretical basis for reliability analysis and risk-based optimal decision making to lifecycle analysis of concrete foundations and towers for wind turbines and bridge elements.

What value do you see the INFRASTAR project bringing to Europe's future infrastructure engineering?

EN: Concrete fatigue is a quite controversial subject in civil engineering – as well as in our consortium. Is the concrete really prone to fatigue? Or is it the reinforcement? Or the connection between both? We hope to be able to shed some light on it. However, there are definitively fatigue effects in concrete constructions, and we will provide methods for monitoring, assessment and risk mitigation. This will help in maintenance planning as well as general infrastructure management.

How are the outcomes of this research, which is very important to society generally, being communicated to the wider public?

JDS: The project is already doing a lot in that direction, using social media. I have never been involved in research projects where this has been done in such a systematic way as it is here.

What are the challenges to ensuring the long-term sustainability of the sector?

EB: We urgently need to leave the beaten path and modernise civil engineering. However, it has become an over-conservative discipline hampered by many standards and codes that refer to knowledge and technology from the last century. This rigid situation has unfortunately become the basic attitude of many and there is little incentive to change and innovate. Sustainability is still a buzzword and not an accepted concept. Personally, I really hope that the younger generation of civil engineers will challenge this situation because society's demand for more sustainable infrastructure will require modernising civil engineering.

Training engineers for the future challenges

INFRASTAR is the ambitious new research and training programme investigating the sustainability of concrete structures and providing early stage researchers with a solid foundation to succeed

The role of structural engineers is changing. As infrastructure ages and new large-scale projects emerge to transform our transportation and energy networks, the future leaders in this field will require a new multidisciplinary approach. 'In many developed countries, concrete infrastructures account for up to 60 per cent of the built environment. In Europe, most of these are now over 40 years old and their service lifetime is becoming a serious issue,' says Project Coordinator Dr Odile Abraham. Furthermore, new innovative concrete towers and foundations for wind turbines will contribute to the further development of cost-effective renewable energy structures.

Developing new ways to monitor fatigue and assess risk and structural reliability are therefore the main aims of the Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk (INFRASTAR) project. Focusing on both existing structures like bridges as well as the emerging market of wind turbine towers, the project is developing generic methods that can be applied to all civil infrastructures while also training 12 early stage researchers (ESRs) to lead this multidisciplinary new field.

A NEW APPROACH TO TRAINING

INFRASTAR consists of 12 ESRs, working within three work packages. The ESRs receive training and conduct research across four world-leading academic institutions and four industrial companies. The project is supported by three partner organisations, which comprise a mix of business and government institutions. These partners provide access to relevant infrastructures and data, and also participate in training weeks and secondments, where they offer scientific and technological information and up to date advice on current practices and precisely where the industry requires new research.

The goals of all training activities are to instil a broad array of skills in the ESRs. Odile Abraham explains: 'A successful scientist in asset management of infrastructures requires a vast toolkit of skills, of which scientific competence is not the only aspect'. Familiarity with the commercial environment, an ability to communicate with a variety of stakeholders, and the capacity to maximise one's creativity and surrounding networks are all essential abilities.

The three training weeks address this by providing courses and experience in communication, economics and business, alongside state of the art training in structural fatigue, technology and probabilistic models. Training weeks also provide ESRs with a chance to reinforce the concept of 'shared objects'. Work package supervisors encourage the ESRs to work on 'shared objects', whether these are real infrastructures, lab specimens and datasets, or software packages. The goals are to put into practise the 'INFRASTAR synergy', to gain skills on team working, and to bring together expertise and viewpoint to produce new knowledge.

BUILDING BETTER BRIDGES AND WIND TURBINES

After just one year an excellent cooperation has been established amongst the group. This cooperation has driven early results which, in turn, are lighting the way forward. For example, a broad overview of the sensors and technologies available for concrete fatigue monitoring has been created, and these shared reports led to a shortlist of the issues to be tackled by INFRASTAR. With a strong foundation set, the first empirical data from experiments are expected in the coming year.

The maintenance and building of civil infrastructure are a major societal issue, as this is the fabric that makes up everything from transportation and energy networks to our commercial and living spaces. Recognising a need to better equip civil engineers to deal with the vast spectrum of issues that encompass this field is the first major success of INFRASTAR. The second will be the graduation of ESRs with the ability to successfully transition into careers in academia, government or industry, and transform the way we build our cities.

Project Insights

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PROJECT PARTNERS

• French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), France • Aalborg University (AAU), Denmark • Federal Institute for Materials Research and Testing (BAM), Germany • Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland • COWI A/S, Denmark • GuD Geotechnik und Dynamik Consult GmbH, Germany • Phimeca, France • NeoStrain, Poland

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Dr Ernst Niederleithinger is INFRASTAR's WP1 Leader and a geophysicist at BAM. He is responsible for the adoption of geophysical methods to NDT, geotechnical application and various other tasks.

Professor Eugen Brühwiler is INFRASTAR's WP2 Leader. He has conducted research on various aspects of existing civil structures since becoming professor of maintenance and safety of structures at the EPFL in 1995.

Professor John Dalsgaard Sørensen is INFRASTAR's WP3 Leader and a professor of civil engineering at Aalborg University. He is President of the Joint Committee of Structural Safety (JCSS), and is involved in several international and national research projects within wind energy and bridge engineering.

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