

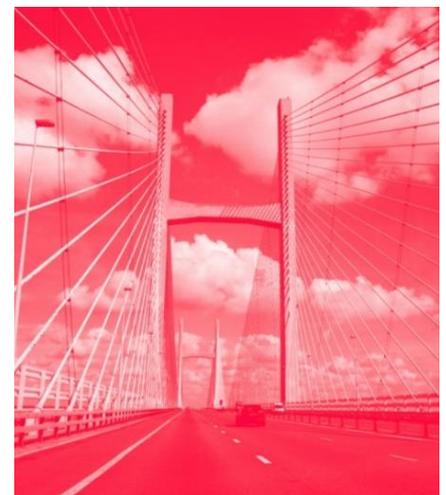


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Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk

NEWSLETTER #04
- February 2019 -





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WELCOME TO THE INFRASTAR NEWSLETTER #04

InfraStar is a **H2020 Marie Skłodowska Curie Actions - Innovative Training Network** project that aims to develop knowledge, expertise and skills for optimal and reliable management of structures in **concrete: bridges and wind turbines** in relation to **fatigue**.

InfraStar addresses 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.

The network partners provide 12 Early Stage Researchers (ESRs) with a system-wide understanding of structure management on bridges and wind energy technology. This outstanding research training offers ranges from knowledge in materials to design loads, design of structures, monitoring of existing structures, development of sensors and innovative calculation methods for structural analysis, optimal and reliable management of structures.

The last InfraStar newsletter #03 was released the 30th of July 2018. Since then, the second implementation day took place at Eiffage, the 12 ESRs have started their 3rd year, and the next InfraStar events are being prepared: the [first InfraStar training school](#) (8-12 April 2019 at Ifsttar, Nantes) and the [third implementation day](#) (26 June 2019 at COWI, Copenhagen).

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By ESR2 Antoine BASSIL.
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TEASER OF THE INFRASTAR NEWSLETTER #04

What are the two questions you should never ask a PhD student?

Find them out at the end of the newsletter...



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GENOA BRIDGE COLLAPSE

Why are SHM systems important and how is Infrastar project contributing?

By [Antoine BASSIL](#) (Early Stage Researcher at Ifsttar). Antoine works on “Distributed fibre optic sensors for crack monitoring in reinforced concrete structures”. Within the framework of his outreach activities, he maintains and updates a [blog](#) on a regular basis. One of his post is about the tragic collapse of the Morandi bridge in Genoa.



“Even if I’m not (yet) a bridge expert, I think this is the best time to put the spotlight on Infrastar project and how we, Early Stage Researchers with the help of our experienced supervisors and the experts from academia and industries, are trying to find answers to many questions covering the different aspects of bridge and wind turbines **design, monitoring and decision-making**.”

The collapse of Morandi bridge in Genoa, leading to at least 39 victims, has opened the discussion about the safety of civil infrastructures, and investigations into the cause of collapse are being led by bridge engineers worldwide. Early speculations are focused on the theory that the collapse was due to **structural failure**. This bridge was designed after World War II in the late 1950s and built in the mid-1960s just like most of the European bridges. However, many experts described its design as 'unusual'. This design was based on the evolved cable-stayed technology and introduced the relatively new pre-stressed concrete technology at that time.

Bridges are the safest of all major structures with a very low risk of fatality. Nevertheless, the statistics date from a time when the vast majority of bridges were within the intended working design life. So what about more than the half a million bridges in Europe that are beyond their 50 years of life?



Morandi bridge after collapse.



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Lack of maintenance

In an [interview](#) given to the French newspaper “Le Monde”, the director of Materials and Structures department (MAST at Ifsttar), Dr.-ing. Jean-Michel Torrenti, claims that the cause could be most probably due to corrosion of pretension cables. Hence, Dr.-ing. Torrenti focuses on the importance of bridge maintenance during the structures life and raises the problem of limited maintenance budget with the question that should be asked: Do we start performing limited repairing procedures equally for different bridges or focus on the most deteriorated ones?

In order to answer this question, we should estimate the remaining life of the structure and then find the best maintenance strategy in order to protect people from events like Genoa bridge collapse while making best economics use of the assets we have. For these reasons, long-term phenomena that affect the structure must be studied. One of the most important phenomena affecting special structures like bridges and wind turbine foundations, exposed to cyclic loading during their whole life, is **fatigue**. Here come the necessity of conducting such a project as Infrastar and its relevance.

In particular, **fatigue reliability assessment** is studied first by [Amol Mankar](#) (ESR9). Then, come the importance of [Morteza AhmadiVala](#)'s (ESR10) and [Lijia Long](#)'s (ESR12) PhD works. While Morteza works on finding optimal maintenance planning, Lijia quantifies the value of information concerning the deteriorated condition of the structure. However, maintenance decisions produce consequences: this is the so-called risk assessment, which is performed by [Sima Rastayesh](#) (ESR11).

In order to improve our understanding of the previously mentioned aspects, information from inspections every 5 years is not enough. In addition, the information provided are usually qualitative more than quantitative, subjective more than objective. So what do we need? SHM!

SHM, Structural Health Monitoring, is still sparsely used!

Happily, the technology we need does exist: it is called SHM, which stands for **Structural Health Monitoring**. SHM systems use sensors to measure the response of the structure to the loads acting on it. It can also monitor local conditions of different parts of the structure (like cracks in **concrete** and corrosion of tendons or reinforcement bars).

In 2007, a similar tragedy happened in Minneapolis with the I-35W bridge collapsing during rush hours (see the picture below). As a result, the new replacement bridge included a '**smart bridge**' system consisting of hundreds of sensors aiming to monitor how the structure bends and deforms in response to traffic loads with the goal of achieving long-term monitoring and studying the bridge's future behaviour as it ages.



The new I-35W bridge in Minneapolis next to the fallen one.



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[Mariia Nesterova](#) (ESR6) also benefits from the weigh in motion system installed in the famous Millau viaduct in order to study the reliability of the structure exposed to traffic and environmental loadings.



Millau Viaduct: the tallest bridge in the world.

There are many examples featuring newly constructed bridges as mentioned in one of my previous [blog posts](#). SHM systems can also be installed on aging bridges like the one installed on Crêt de l'Anneau bridge in Switzerland (see the figure below). The system was installed in order to prove that, contrary to the standard codes, this bridge is not damaged by fatigue and can still serve more than its age limit. This is part of [Imane Bayane](#)'s (ESR4) work. She studies fatigue parameters and uses different types of sensors and **Non Destructive Testing** (NDT) techniques. Then, [Joyraj Chakraborty](#) (ESR3) uses data fusion techniques to improve sensors capacity to detect defects.



Crêt de l'Anneau bridge in Switzerland.

Professor Eugen Brühwiler from EPFL (work package 2 leader) mentioned in his interview with Radio Télévision Suisse the use of the Ultra High Performance Fibre Reinforced Concrete (UHPFRC) for reinforcement of Chillon viaduct (see the figure below). This is exactly what [Bartek Sawicki](#) (ESR5) focuses on by studying the long-term fatigue behaviour of structures conceived with this special material.



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The use of UHPFRC for the Chillon viaduct is a world first, not only in terms of the area to be covered, but also the volumes to be produced and installed in a short period of time.

Talking about novel sensors and NDT techniques, and meanwhile [Xin Wang](#) (ESR1) focuses on the implementation of **Coda Wave Interferometry** (CWI) technique for real time monitoring of subtle changes in the structure behaviour, I, [Antoine Bassil](#) (ESR2) put the focus more on exploring the capacity of **Distributed Fibre Optics Sensing** techniques for crack monitoring and quantification of crack openings. Fibre Optics Sensors are now one of the most established types of sensors in SHM systems providing very rich information about strain and therefore stress over large distances inside different types of civil structures like bridges.

InfraStar focuses on the prediction of concrete infrastructures behaviour under fatigue such as bridges but also the foundations of wind turbines that are part of the works by [Gianluca Zorzi](#) (ESR7) and [Joey Velarde](#) (ESR8).

This is a short and brief overview about what InfraStar project aims to achieve and how it pushes young researchers like us into playing a role in making civil engineering structures safer and more reliable and extending the life of bridges that influence the growth and quality of life of citizens and reflect their ideas and cultures.”



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PAST EVENTS

Implementation day #02

The purpose of the implementation days is to invite small and large companies, administrations, local authorities, academic experts in the fields of Infrastar in order to get their feedback on the progresses and to boost the networking opportunities. In other words, it offers to meet, exchange ideas and gain insights from each other.

It is the opportunity for the ESRs to meet people with similar research interests leading to fruitful collaborations. For instance, Mariia Nesterova (ESR6) met Marcel Nowak (TU Munich) during the ImpDay#01 and they are now working together towards two conference papers about traffic simulations and extreme value theory application in bridges.

The second implementation day (ImpDay#02) was organised jointly with [EIFFAGE](#) in Vélizy-Villacoublay (France) on Friday, the 12th of October 2018.

Part of Infrastar project as a partner organisation, Eiffage is a leading figure in the European concessions and public works sector, operating through four divisions: construction, infrastructures, energy systems, and concessions.

More information on Infrastar website [here](#).





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Networking is the heart of the Infrastar Implementation Days.



"My thesis in 180s" by Gianluca Zorzi (ESR7).



"My thesis in 180s" by Joey Velarde (ESR8).



Poster session.



Round table on "NDT parameters for fatigue damage identification in structural elements".



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WHAT'S ON THE INFRASTAR AGENDA?

First InfraStar Training School

The 1st InfraStar training school is scheduled from the 8th until the 12th of April 2019 at Ifsttar Nantes (France). Visit <http://trainingschool.infrastar.eu/> for more information.

Who should attend? The InfraStar training schools aim to provide lectures and hands-on trainings to Master and PhD students, early-stage researchers, young professionals on all aspects of asset management of civil infrastructures with respect to fatigue of materials. The participants will get additional knowledge about their own field but also about what is performed beforehand and afterwards.

Do not miss the opportunity to be trained and to discuss about fatigue and reliability analysis of structures with a **unique international scientific panel**:

- Prof. John Popovics (University of Illinois, USA)
- Dr Marc Thiele and Dr Ernst Niederleithinger (BAM, Germany)
- Dr Odile Abraham and Dr Franziska Schmidt (Ifsttar, France)
- Prof. Eugen Brühwiler (EPFL, Switzerland)
- Prof. John Dalsgaard Sørensen (AAU, Denmark)
- Assoc. Prof. Sebastian Thöns (DTU, Denmark)

The courses will provide multi-disciplinary and intersectoral basic concepts in three core fields, ranging from the design to the dismantling of the structures (bridges and wind turbines):

1. Monitoring and auscultation.
2. Structure and action models.
3. Reliability, risk and decision analyses.

A participant who successfully has taken part in the InfraStar training school will be able to understand:

1. How to smarten the structures and its benefits.
2. How to model structural and material behaviours under loading.
3. How to develop, perform and assess structural risks and the value of structural information.

Implementation day #03

The [third implementation day](#) is scheduled for Wednesday 26th June 2019 at COWI in Copenhagen, Denmark.

The focus will put on the work package 3: Reliability approaches and decision-making.



More information available soon. Stay tuned...



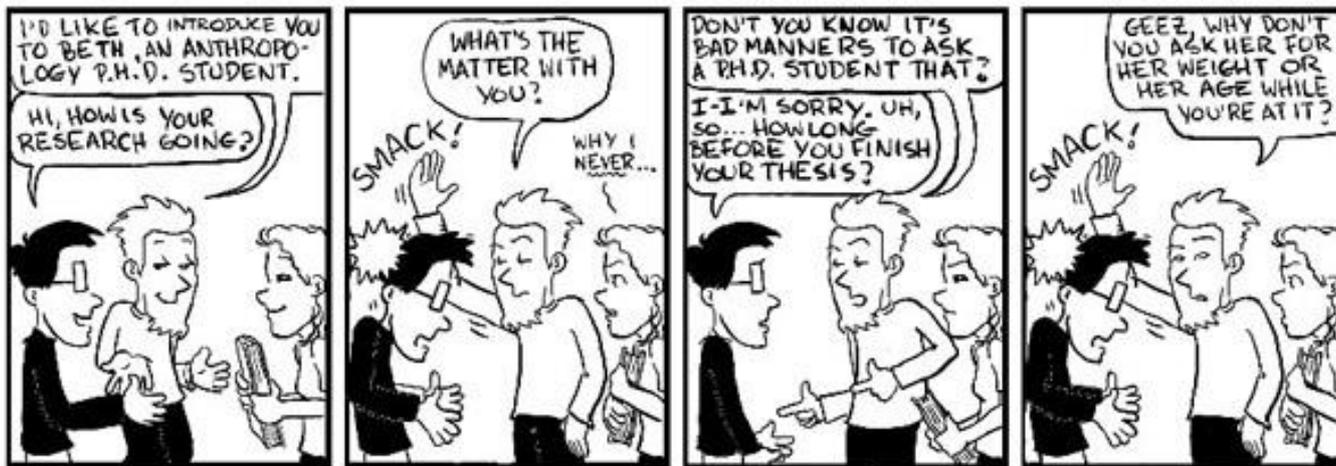
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TEASER OF THE INFRASTAR NEWSLETTER #03

What are the two questions you should never ask a PhD student?

1. How is your research doing?
2. How long before you finish your thesis?



JORGE CHAM © THE STANFORD DAILY

MORE INFORMATION ON INFRASTAR WEBSITE AND SOCIAL MEDIA, STAY TUNED...





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PHOTO GALLERY



InfraSTAR team in Paris #ImplementationDay



ImpDay#02 : Lunch & networking



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ESR1 Xin Wang's secondment at NeoStrain working with Joyraj Chakraborty (ESR3).



Antoine Bassil (ESR2) and Joey Velarde (ESR8) seconded at EPFL and working with Imane Bayane (ESR4), Bartek Sawicki (ESR5) and Prof. Eugen Brühwiler.



Lijia Long (ESR12) seconded at COWI and working with Dr Isaac Farreras Alcover.



ESR6 Mariia Nesterova's secondment at COWI, working with Dr Katerina Konakli.



"Welcome to COWI".



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LIST OF PUBLICATIONS

Journal papers

- Bassil A., Wang X., Chapeleau X., Niederleithinger E., Abraham O., Leduc D.
Distributed Fiber Optics Sensing and Coda Wave Interferometry Techniques for Damage Monitoring in Concrete Structures
Sensors, Volume 19, Issue 2, January 2019
- Chakraborty J., Katunin A.
Detection of structural changes in concrete using embedded ultrasonic sensors based on autoregressive model
Diagnostyka, Vol.20, No. 1, 2019
- Niederleithinger E., Wang X., Herbrand M., Müller M.
Processing ultrasonic data by coda wave interferometry to monitor load tests of concrete beams
Sensors, Volume 18, Issue 6, June 2018
- Thöns S., Döhler M., Long L.
On Damage Detection System Information for Structural Systems
Structural Engineering International, Volume 28, Issue 3, pages 255-268, 2018

Conference papers

- Abraham O., Niederleithinger E., Chapeleau X., Klikowicz P., Brühwiler E., Bassil A., Wang X., Chakraborty J., Bayane I., Leduc D., Salamak M., Katunin A., Sørensen J.D.
Addressing the need to monitor concrete fatigue with Non Destructive Testing: preliminary results of InfraStar European project
SMT and NDT-CE 2018 - Structural Materials Technology for Highways and Bridges (SMT) and the International Symposium on Non-Destructive Testing in Civil Engineering (NDT-CE), New Brunswick, New Jersey, USA, 27-29 August 2018
- Bayane I., Brühwiler E.
“Pocket-Monitoring” for fatigue safety verification of a RC bridge deck slab
IALCCE 2018, The Sixth International Symposium on Life-Cycle Civil Engineering, Ghent, Belgium, 28-31 October 2018
- Long L., Thöns S., Döhler M.
The effects of deterioration models on the value of damage detection information
IALCCE 2018, The Sixth International Symposium on Life-Cycle Civil Engineering, Ghent, Belgium, 28-31 October 2018
- Mankar A., Rastayesh S., Sørensen J.D.
Fatigue reliability analysis of Cret De l'Anneau viaduct: A case study
IALCCE 2018, The Sixth International Symposium on Life-Cycle Civil Engineering, Ghent, Belgium, 28-31 October 2018
- Mankar A., Sørensen J.D.
Fatigue reliability analysis of onshore wind turbine foundations
14th EAWC PhD Seminar on Wind Energy, Vrije Universiteit Brussel, Belgium, 18-20 September 2018



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- Niederleithinger E., Wang X.
Concepts from seismic interferometry transferred to sonic and ultrasonic concrete inspection and monitoring
ECNDT 2018, The 12th European Conference on Non-Destructive Testing, 11-15 June 2018, Gothenburg, Sweden
- Rastayesh S., Sørensen J.D.
Risk analysis for wind turbines near highways
The 4th SRA Nordic Conference, Stavanger, Norway 8–9 November 2018
- Rastayesh S., Nielsen J.S., Sørensen J.D.
Bayesian network methods for risk-based decision making for wind turbines
14th EAWC PhD Seminar on Wind Energy, Vrije Universiteit Brussel, Belgium, 18-20 September 2018
- Sawicki B., Brühwiler E., Nesterova M.
Fatigue safety verification of a steel railway bridge using short term monitoring data
IALCCE 2018, The Sixth International Symposium on Life-Cycle Civil Engineering, Ghent, Belgium, 28-31 October 2018

More information on INFRASTAR website [here](#).