MARIE CURIE ACTIONS

INFRASTAR

INFRASTAR

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

NEWSLETTER #02
- November 2017 -
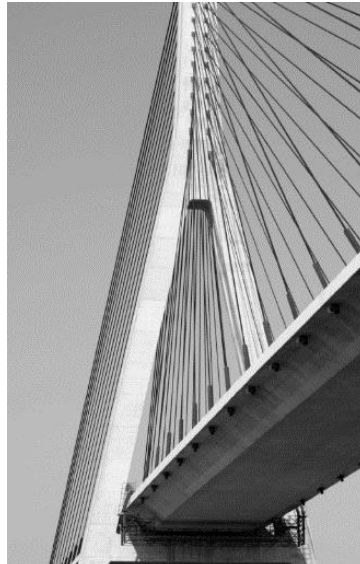
IFSTTAR   PHIMECA   AALBORG UNIVERSITET   BAM   COWI

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE   GD   NeoStrain TECHNOLOGIE POMIAROWE   EIFFAGE   bast

FOREWORDS

After the lengthy work of coordinating the submission of INFRASTAR project to the European Commission call, came the time of launching the INFRASTAR boat first by making a successful recruitment campaign: in addition to a dedicated project manager, the centre pin of the project everyday life, 12 high-level motivated young researchers now guaranty high standard research work. This challenge has been described in the first newsletter.

Now, after more than one year, INFRASTAR is running normal speed. Our ESRs have formalized individual state of the arts, deepen the understanding of their individual project, and internalize the global frame of INFRASTAR. Nonetheless everything is not done, consolidation of the first year is still at work. It is the coordinator's role to make this project a chance for each ESR not only to make a brilliant PhD in their institution but also to collaborate closely with other ESRs so that 1+1 is superior to 2. This is indeed a central idea of Marie Skłodowska-Curie ITN that gives a chance to ESRs to embrace all the whys and wherefores of their research work. This aim has arrived at a stage where all partners are invited to put their efforts. The ESRs are encouraged, by the work package leaders and their supervisors to work together on what we have called "shared objects". These shared objects are either real structures (bridges or wind turbines) or lab test specimen. Shared objects can also be data sets or specific software. The first secondments have been a great opportunity to make the ESRs think and work this way: it will be exemplified during the first implementation day in Germany where joint presentations will be made by the ESRs, and also later on by joint publications.

A major focus for the coordination team, together with the smooth planning of the training sessions and the dissemination events where all the ESRs are gathered and pushed to mixed their knowledge and expertise, is thus to consolidate this spirit. The coordination team is indeed here to help all ESRs to benefit from INFRASTAR framework in order to build and strengthen their career plan as well as to produce high-level scientific work.

Dr. Odile Abraham

Project coordinator

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Welcome to the INFRASTAR newsletter #02. In this issue:

- Focus on how the collaboration between all the ESRs is fostered:
  - Secondments.
  - Shared objects.

- Overview of the first year of research: the floor is given to the work package leaders and the ESRs.
  - Work package 1: Monitoring and auscultation.
  - Work package 2: Structural and action models.
  - Work package 3: Reliability approaches for decision-making.

- List of publications.

- New partner organisation: VALEMO.

- What's on the INFRASTAR agenda?

INFRASTAR team at the first training week at BAM (Berlin) in March 2017.

BREAKING NEWS

"Fatigue does not exist…", Prof. Eugen Brühwiler says.

More details at the end of the newsletter…

HOW THE COLLABORATION BETWEEN ALL THE ESRs IS FOSTERED

Secondments

Every ESR will carry out between 2 and 3 secondments of 1 to 3 months at beneficiaries and/or partner organisations of the project. The main objectives are to:

- Establish a close relationship between the ESR and the co-supervisor and ensure that the network's synergy truly operates.
- Generate common publishable results between partners.
- Gain additional technical and transferable skills.
- Expose the young researchers to different organisations, environment and cultures.

Shared objects

In order to foster the collaboration and the networking between all the ESRs, a list of "shared objects" has been set, which includes bridges, wind turbines, and reference models.

- **Kwidzyń bridge in Poland**
  Extradosed bridge completed in 2013 / 3 flyovers / Overall length: 1867.2 m
  Strain and displacement sensors, accelerometer, inclinometers.

- **Rędziński bridge in Poland**
  Cable-stayed bridge, completed in 2011 / 2 flyovers / Overall length: 1742.0 m
  Heavily instrumented by NeoStrain. One of the more instrumented bridges in the world.

- **Bridge over Kłodnica river in Poland**
  12 span continuous beams / Overall length: 552 m

- **Chillon viaduct in Switzerland**
  Strengthened in 2014-2015 using UHPFRC.

- **Crêt de l'Anneau viaduct in Switzerland**
  Monitoring of deck slab: in-situ traffic action effect, fatigue.

- **Millau viaduct in France**
  Cable-stayed bridge, completed in 2004 / Overall length: 2460.0 m

- **Onshore wind turbine in Switzerland**
  Vestas V90 2.00 MW / 95 m high, 90 m rotor diameter.

- **Onshore wind turbine in France**
  Senvion MM92 2.05 MW / 100 m high, 92.5 m rotor diameter.

- **BLEIB reference structure in Germany**
  Large-scale model to evaluate various damage detection and monitoring system.

Kwidzyń bridge, Poland

Bridge over the Kłodnica river Poland

Millau viaduct, France

Rędziński bridge Poland

Chillon viaduct Switzerland

Crêt de l'Anneau viaduct Switzerland

BLEIB reference structure Germany

Onshore wind turbine France

Onshore wind turbine Switzerland

WORK PACKAGE 1: MONITORING & AUSCULTATION

The Work Package **Monitoring and Auscultation** (WP1) focuses on **advanced monitoring** and **non-destructive testing** (NDT) techniques for **stress** and **strain** measurements and **fatigue damage** assessment.

The first year of INFRASTAR in WP1 was focused on documenting the state of the art, connecting the ESRs for a fruitful cooperation and performing first experiments. The state of the art reports delivered by the ESRs in spring have been compiled to a deliverable. While Xin (ESR1) and Antoine (ESR2) focused on their specific investigation methods (ultrasonic and fibre-optic), Joyraj (ESR3) and Imane (ESR4) gave as expected a broader overview on sensors and technologies available for concrete fatigue monitoring. The reports helped us to compile a specific shortlist of issues we will work on in INFRASTAR.

From May to July, Xin (ESR1) went to Nantes for a secondment at IFSTTAR. He worked with Antoine (ESR2) on experiments to compare the results of fibre-optic to ultrasonic monitoring. The experiments were only partly successful, which is in fact good, because it helped to identify several issues, which have to be solved before practical application of these technologies. For example, a simple data acquisition box developed at BAM has to be upgraded to fulfil the needs.

In August, Joyraj (ESR4) arrived at BAM for a three-month secondment. He participated in BAM' advanced NDT training. Together with Xin (ESR1) he went to a summer school in Italy on materials behaviour. After their return, they were joined by Imane (ESR4). Together they participated in load tests on a bridge model ("BLEIB reference structure") on BAM's test site. They prepared and performed ultrasonic experiments and got insight to other technologies (e.g. acoustic emission, optical techniques). They were faster than any other group participating in the experiment in preparing preliminary results and showed that the ultrasonic techniques worked quite well, while most optical fibres broke.

The joint work on the BLEIB structure will be continued, when Antoine (ESR2) will arrive in Berlin in November for his secondment at GuD.

Dr. Ernst Niederleithinger

WP1 Leader

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BAM

Project 1: Advanced instrumentation for interferometric monitoring

ESR1 @ BAM

Xin Wang
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Project webpage

BAM

During the first year, I wrote a state of the art about my PhD thesis.

From April to June, I tested a new "BAM-made" data acquisition and monitoring system "W-BOX" during my secondment at IFSTTAR in Nantes (France), and worked together with Antoine (ESR2) who works on fibre optics. Unfortunately, the W-BOX has some issues. However, at least, we found out how to improve the W-BOX.

In July, I participated in a summer school on "Smart Materials & Structures" in Italy.

In August, I did dynamic and static tests on the BLEIB structure with embedded ultrasonic sensors (SO807) installed inside the structure. Therefore, for the near-future plan, I will focus on analysing the data from BLEIB structure, write a paper with Joyraj (ESR3) and improve the W-BOX. It would be great if the W-BOX could be put into use.

XIN'S road taken during the first year

With Joy, Imane, Lijia

With organizers

Install sensors

With Ernst

Presentation

CCG workshop

Install new sensors

All my colleagues

09/17 — Test on BLEIB structure Horstwalde
09/17 — PhD day in BAM, Berlin Presentation of our PhD topics and IFRASTAR
07/17 — Summer school: 'Smart Materials & Structures' Trento, Italy
04
05
06/17 — Secondment in Ifsttar, Nantes
03/17 — First training week in BAM, Berlin
03/17 — Workshop: 'Giving presentation in English' BAM, Berlin
02/17 — Workshop: 'Digital signal analyzing', BAM, Berlin
11/16 — First business trip to Aachen
10/16 — Start my PhD in BAM, Berlin

INFRASTAR   BAM

Project 2: Fibre-optic sensor for fatigue monitoring
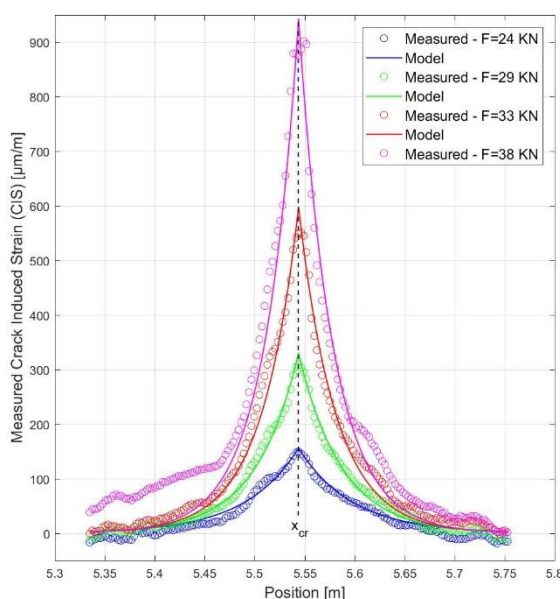
ESR2 @ IFSTTAR

**Antoine Bassil**
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Project webpage

My first year was divided into two parts. The first 5 to 6 months were focused on the state of the art work trying to explore the structural health monitoring research field in civil engineering while focusing on fiber optic sensors mainly distributed optical fiber sensor's technology (DOFS) for crack detection in concrete. This work was developed into a state of the art report and presented on many occasions like the first INFRASTAR training week in Berlin and COSYS / IFSTTAR doctoral day in Paris.

The second part of the year was focused on performing my first experimental tests on concrete beams. These tests were the subject of common work with ESR1 Xin Wang from BAM working on Coda Wave sensors. The results showed the efficiency of DOFS to detect cracks and monitor them even at high crack width (500 µm).

The picture below shows the measured Crack Induced Strain (CIS) distribution near the crack. The characteristic plot relating CIS measured (at crack's location) to the Crack Opening Displacement (COD) shows a linear and nonlinear part until reaching a maximum strain value.
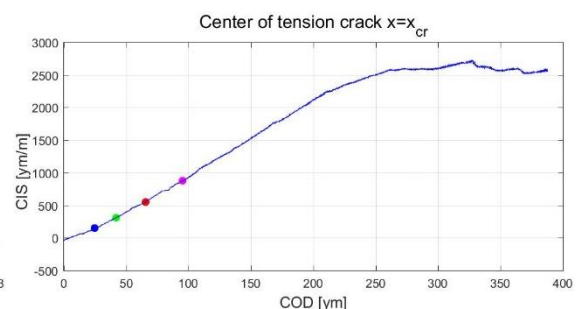
Mechanical transfer function model applied on an experimental test.

Project 3: Sensor integration, data fusion and information management for industrial monitoring systems

ESR3 @ NeoStrain

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Project webpage

The first year at NeoStrain in WP1, I was focused on writing the state of the art, getting familiar with embedded ultrasonic sensors and preparing first experiments. My state of the art was an overview of signal processing techniques and Non-Destructive Testing by different sensors for bridge/concrete monitoring.

Then from July to September, I went to BAM in Berlin for my secondment. There I have participated in advance NDT training and I performed the embedded ultrasonic experiment with Xin (ESR1) in load test experiment on a bridge model ("BLEIB reference structure") on BAM's test site (see the picture below). Then we have started to analyse the ultrasonic data using different signal processing techniques (coda wave, window based split spectrum processing) and showed preliminary results.

My upcoming milestone is to find signal de-noising technique to improve the visibility of the ultrasonic wave propagation especially pair of the ultrasonic transducer and receiver, which are far from each other, and the presence of noise. And the second step is to feature extraction from this sensor!

Load test experiment on BLEIB structure.

Project 4:   NDT parameters for fatigue damage identification in structural elements

ESR4 @ EPFL

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Project webpage

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Main work:

- Preparation of the state of the art.
- Processing one year of data recorded from a mixed-concrete-steel bridge to understand structural behaviour and to evaluate fatigue safety.
- Investigation of the effect of temperature on measured data.
- Evaluation of different non-destructive-test techniques during Berlin secondment to choose the ones that can detect fatigue quantitatively not just qualitatively.
- Introduction to coda wave and embedded sensors to detect damage inside cement matrix.

Future work:

- Complete investigation of the effect of temperature on structural behaviour and measured data.
- Collaboration with ESR12 Lijia to quantify the value of structural health monitoring information on the bridge under study.
- Collaboration with ESR3 Joyraj to introduce ultrasonic test for damage detection on the bridge under study.
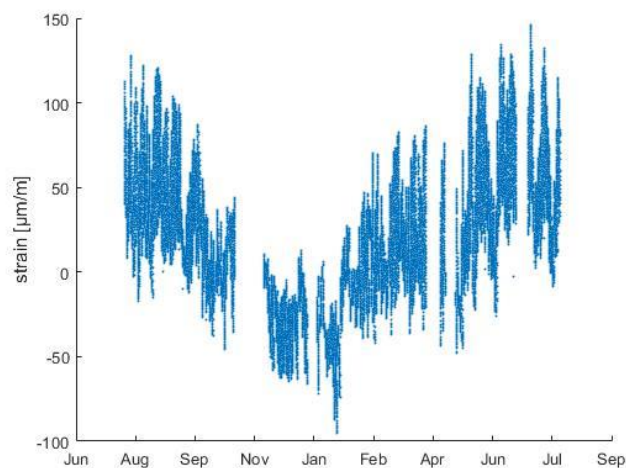
Annual measured strain for a mixed bridge (longitudinal rebar).

WORK PACKAGE 2: STRUCTURAL & ACTION MODELS

The Work Package **Structural and Action Models** (WP2) focuses on **structural and fatigue loading models**.

The first year of Work Package 2 was focused on establishing the state of the art on "Fatigue of reinforced concrete components of bridges and wind turbines". In particular, the state of research of the four themes investigated by the four ESRs was established:

1) Fatigue of reinforced concrete structural elements (ESR5).

2) Reliability of structures exposed to traffic loads and environmental loading (ESR6).

3) Lifetime cyclic behaviour of gravity base foundations for offshore wind turbines (ESR7).

4) Fatigue of wind turbine concrete structures (ESR8).

This led to the Deliverable 2.1 delivered end of May 2017.

Since June 2017, the specific research topics are further studied by the four ESRs with the objective to establish the research questions that will be analysed and answered during the respective doctoral research work. For this, analytical and numerical models are used to explore possible research avenues. Also, data from monitoring of bridges and wind turbines are analysed. During their secondments, the ESRs got insight into research methodologies present at partner institutions. The specific research questions and research plans of each ESR will be discussed during the upcoming Training Week at EPFL in Lausanne, Switzerland. In the second year, first original research results are expected and will be presented at the IALCCE Conference in October 2018 during a special session devoted to INFRASTAR.

Prof. Eugen Brühwiler

WP2 Leader

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Project 5: Fatigue of reinforced concrete structural element

ESR5 @ EPFL

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Project webpage

I have started my work within INFRASTAR in the beginning of this year. During those nine months, I have learned a lot.

Firstly, my work was focused on literature study, which should be the starting point of all the research. I have been also following courses on signal processing and fracture mechanics - the former was useful during short-term monitoring of railway bridge (see the picture below) while the latter helps in understanding the fatigue phenomenon.

I cooperate with other ESRs - with Mariia (ESR6) we are working on paper about the bridge monitoring, and with other colleagues from Denmark (Joey ESR8, Amol ESR9 and Sima ESR11) we took part in summer school at DTU during my secondment at AAU.

Now, I am finalizing works on probabilistic fatigue model of concrete, which will be useful for WP3, and soon I will plan the experimental campaign to investigate the fatigue of UHPFRC.

Historic bridge across river Kander near the village of Eifeld, in Bern Canton.

Project 6: Reliability of structures exposed to traffic loads and environmental loading

ESR6 @ IFSTTAR

Mariia Nesterova
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Project webpage

Thanks to the fulfilled and active schedule of the project INFRASTAR, the beginning of my PhD has been very interesting and progressive. Attending several training weeks and seminars, participating in the department video competition, presentation at the CFM conference, and this is just the first year!

As main results, in addition to the state of the art and outreach activities, the paper for the CFM2017 conference proceedings has been published, and materials for a journal paper about bridges lifetime predictions are collected. Moreover, the first secondment of three months at EPFL in Lausanne was a great experience. It allowed me to enrich knowledge in the field of fatigue and to work together with other researchers with following common publications.

Two more years are in front of me, and I hope to have new results obtained and presented as well as a few more papers to be published.
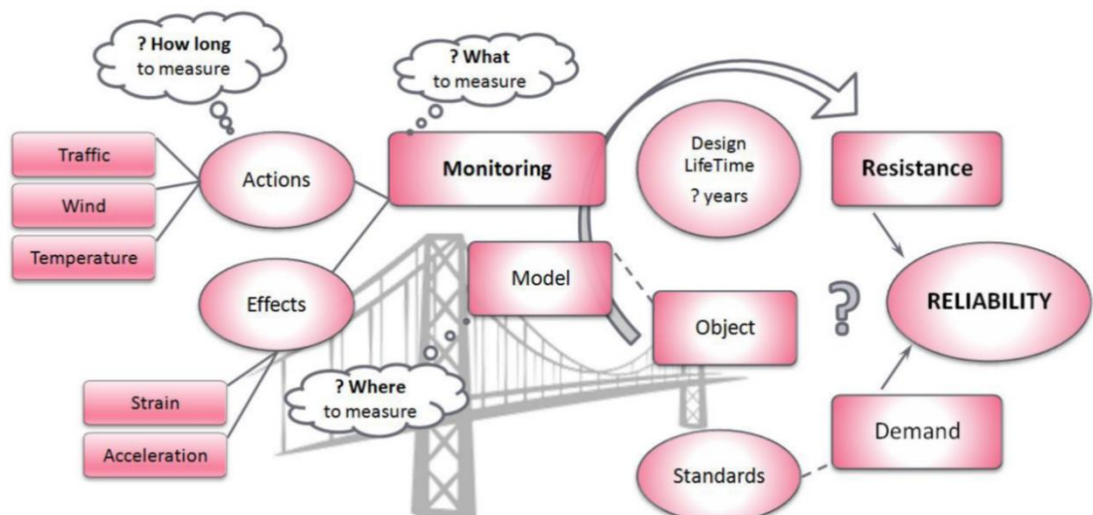
Project 7: Lifetime cyclic behaviour of gravity base foundations for offshore wind turbines

ESR7 @ GuD

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Project webpage

Modelling the behaviour of granular materials under cyclic loading by means of constitutive relations is a well-known challenge. To achieve this goal, very complicated and phenomenological constitutive relations have to be developed from macroscopic observations.

An alternative approach is the multiscale coupling FEM-DEM. The Finite Element Method (FEM) is used to solve boundary value problems, while the Discrete Element Method (DEM) is used to derive the characteristic behaviour of granular materials.

The bigger picture of the present project is to use the multiscale coupling to solve common geotechnical problems. In order to reach this goal, in the past year some initial benchmarks of the coupling FEM-DEM have been done by modelling experimental monotonic drained triaxial tests with glass balls and sand. The results show a high congruence in terms of stress and strain. And in the future, the cyclic loading conditions will be addressed.
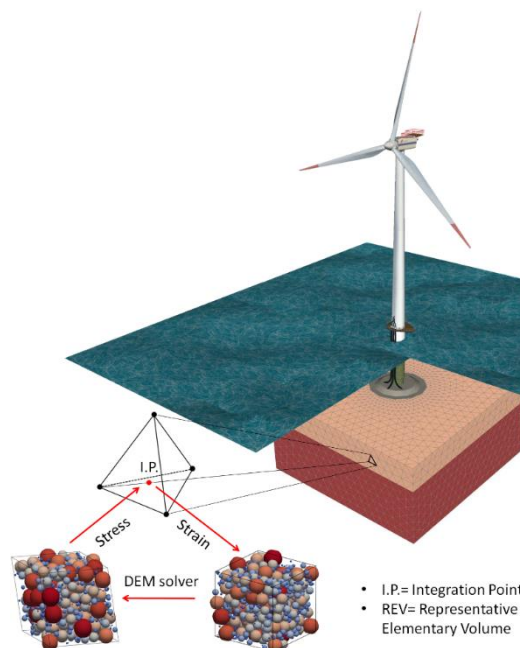
Multiscale modelling FEM-DEM [Combined work with Sketchup 3dwarehouse].

Project 8: Fatigue of wind turbine concrete structures

ESR8 @ COWI

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Project webpage

The first 11 months of the PhD study mainly focused on
1) the development of research plan and state-of-the-art study,
2) the participation in PhD courses and
3) the development of the offshore wind turbine model.

An offshore gravity based foundation (GBF) designed by COWI was taken as a reference design. The simulation tool HAWC2 was used to develop the GBF numerical model, which will be used for future analyses. In addition, a sensitivity analysis of the model was performed where the most influential input parameters that affect fatigue loads were identified. Using the developed GBF model, the study will proceed by evaluating different methods for modelling both soil-structure interaction and hydrodynamic loads. The influence of wind-wave misalignment to fatigue under certain conditions will also be examined.
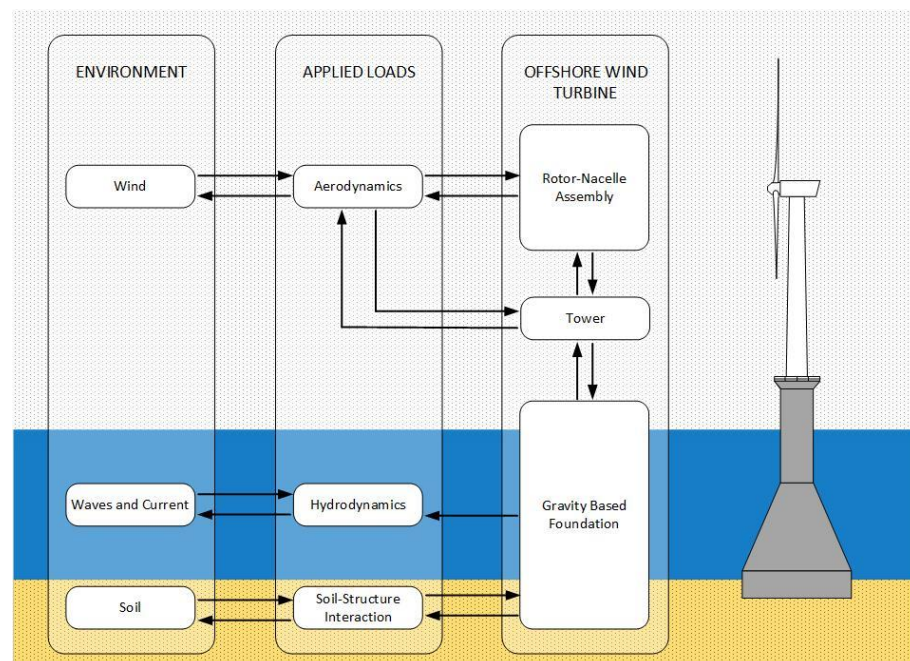
Components of integrated design and analysis of an offshore wind turbine.

WORK PACKAGE 3: Reliability Approaches for Decision-Making

The Work Package **Reliability Approaches for Decision-Making** (WP3) has the objective to apply the theoretical basis for reliability analysis and risk-based optimal decision making for **life cycle analysis** to **concrete foundations** and towers for wind turbines along with bridge elements.

In Work Package 3 "Reliability Approaches for Decision-Making" applications are for wind turbine concrete foundations and towers and for concrete bridge elements. All four ESRs have started their PhD studies, state-of-the-art reports have been prepared, and many PhD courses taken providing a solid basis for the research.

Relevant shared objects are been selected – one issue here is that in some cases it is difficult to get wind turbine specific data. Secondments have started, e.g. the last month 4 of the ESRs were at Aalborg University making it possible to discuss and plan common activities.

In November, the next training week will take place providing more common theoretical basis for stochastic modelling, reliability analyses and risk analyses of wind turbines and bridges.

Prof. John Dalsgaard Sørensen

WP3 Leader

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AALBORG UNIVERSITET

Project 9:   Fatigue reliability of concrete wind turbines and bridge elements

ESR9 @ Aalborg University

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Project webpage

AALBORG UNIVERSITET

Last year December 1st, I joined in Aalborg University as PhD fellow in a prestigious ITN project INFRASTAR funded by European Union and almost completed one year.

I have completed 24 credits through various PhD courses available at Aalborg University, DTU and training week in Berlin organised by INFRASTAR and BAM. Through all these courses and trainings, I learned a lot on various fronts improving my communication skills, interpersonal skills on international level, statistical knowledge, knowledge about wind turbine industry, knowledge on structural reliability.

Mostly I worked on material model part for fatigue of concrete and made a stochastic model for concrete fatigue based on large databank searched through literature. Developed algorithms in MATLAB for structural reliability analysis reading Markov matrix from wind turbine using FERUM (Finite Element Reliability Using Matlab) its open source MATLAB tool.
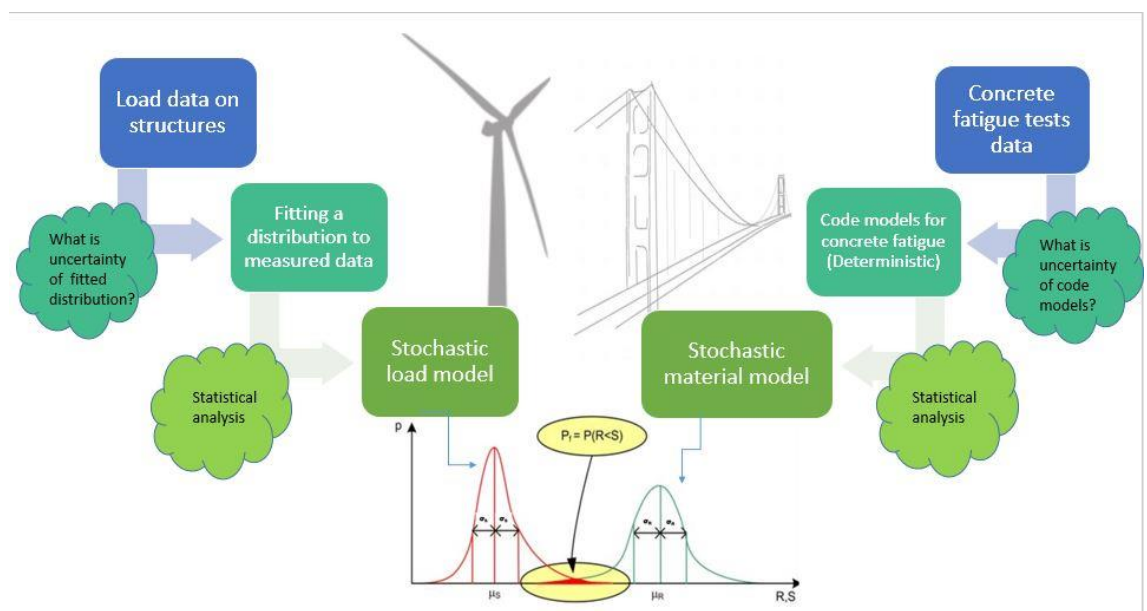
Project 10: Optimal maintenance planning of existing structures using monitoring data
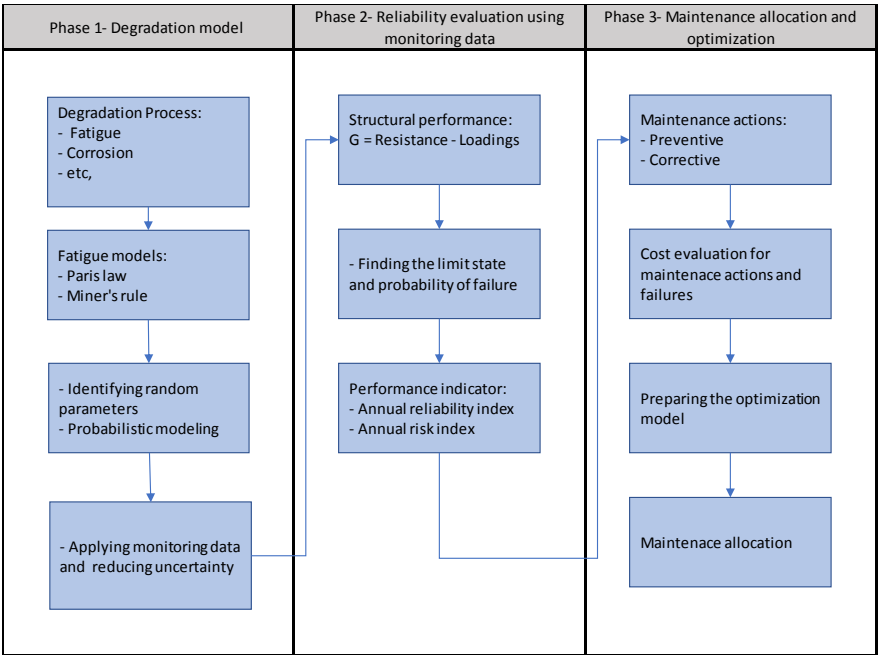
ESR10 @ PHIMECA

Morteza Ahmadivala
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Project webpage

As it can be understood from my project topic, there are some main issues needs to be addressed for structural optimal maintenance planning. First, the decision about structural limit state should be made which for this project, fatigue degradation has been chosen as the limit state. Second, selection of a proper methodology for fatigue reliability analysis needs to be addressed, and in the last step, an appropriate cost modelling would be helpful to be employed for allocating optimal maintenance actions. Also, exploiting the extra information coming from monitoring data will help to reduce the uncertainty within the degradation process.

So far, my main duties among this period (7 months) was to study the literature to identify different approaches to tackle these main issues in structural maintenance planning and to provide a general framework for my project. Since uncertainty quantification and using monitoring data is one of the main issues in my project, my main duty for the next step would be achieving some monitoring data from our shared objects and trying to reduce uncertainty in fatigue degradation process by applying monitoring information about structural real life conditions within a proper and novel framework.

Phase 1- Degradation model	Phase 2- Reliability evaluation using monitoring data	Phase 3- Maintenance allocation and optimization
Degradation Process: - Fatigue - Corrosion - etc,	Structural performance: G = Resistance - Loadings	Maintenance actions: - Preventive - Corrective
Fatigue models: - Paris law - Miner's rule	- Finding the limit state and probability of failure	Cost evaluation for maintenace actions and failures
- Identifying random parameters - Probabilistic modeling	Performance indicator: - Annual reliability index - Annual risk index	Preparing the optimization model
- Applying monitoring data and reducing uncertainty		Maintenace allocation

A general framework for structural maintenance planning under fatigue using monitoring data.

Project 11: Development of methods for risk assessment of wind turbine support structures and bridges

ESR11 @ Aalborg University

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Project webpage

It is now 10 months that I have started my Ph.D. at Aalborg University. The topic of my Ph.D. is: Development of methods for risk assessment of wind turbine support structures and bridges, the project is funded by ITN project INFRASTAR European Union. During this time, I passed a lot of courses and training. In the first two months, I uploaded a two month plan of my Ph.D. So I started to read and I also wrote a state of the art report as well. I went to a training in Berlin planned by INFRASTAR and gave a presentation of my state of the art. I participated in a summer school at DTU. There, I understood the uncertainty and sensitivity analysis. Which I want to apply it to a bridge. I am now working with other ESRs on various topics related to risk assessment of wind turbine and bridges and preparing an updated version for my Ph.D. plan.
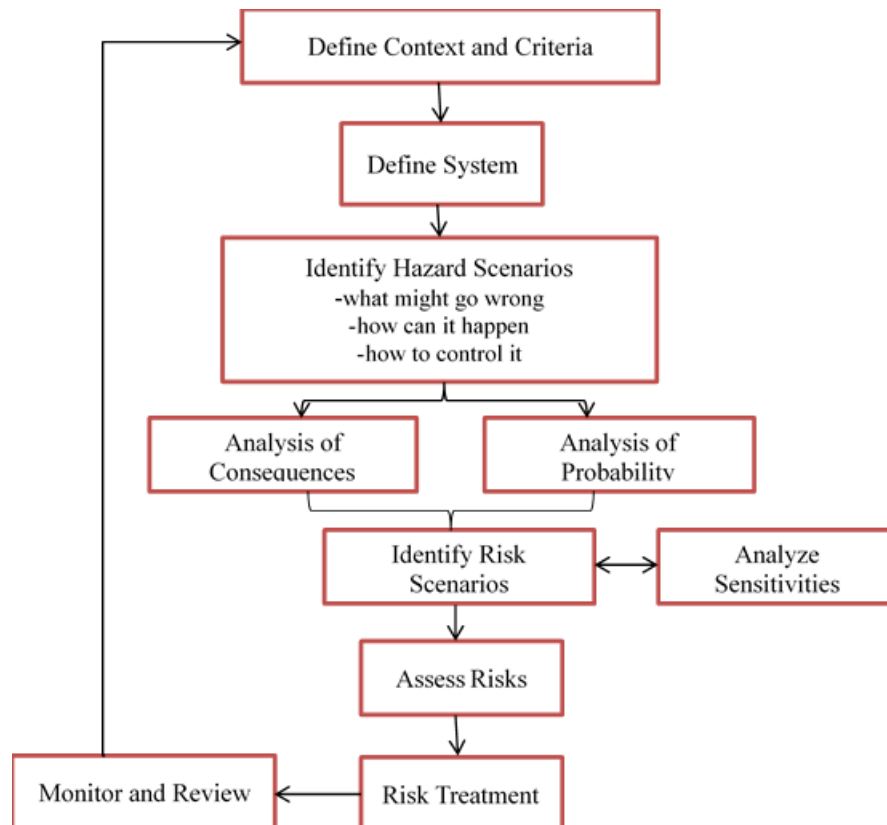
General scheme for risk-based decision analysis.

Project 12: Quantification of the value of monitoring information for deteriorated structures

ESR12 @ BAM

**Lijia Long**
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Project webpage

Until October 2017, I published 1 conference paper (Lijia Long, Sebastian Thöns, Michael Döhler. Damage Detection and Deteriorating Structural Systems. IWSHM - 11th International Workshop on Structural Health Monitoring, Sep 2017, Stanford, United States), attended 2 outreach activities (I gave a presentation in PhD Retreat and made a poster in PhD day in BAM), attended 2 training schools (one training week organized by INFRASTAR in BAM, Berlin and one summer school organized by The International Max Planck Research School (IMPRS) in Magdeburg, Germany).

I will attend 2 more training schools in November (one will be held by COST TU1402 in Italy and another one will be organized by INFRASTAR in EPFL, Switzerland). Currently I am writing two scientific papers on quantification the value of damage detection information.

Cooperation with others ESRs are ongoing. Imane (ESR4) and I, we have ideas to carry out a quantification analysis of SHM values on a bridge in Switzerland named Crêt de l'Anneau viaduct. A risk analysis of wind turbine under icing environment is planning to be done between Sima (ESR11) and me. Hope more results will be published in 2018. I am also planning to take more courses or training schools next year.

Lijia's PhD Journey 2017-2018
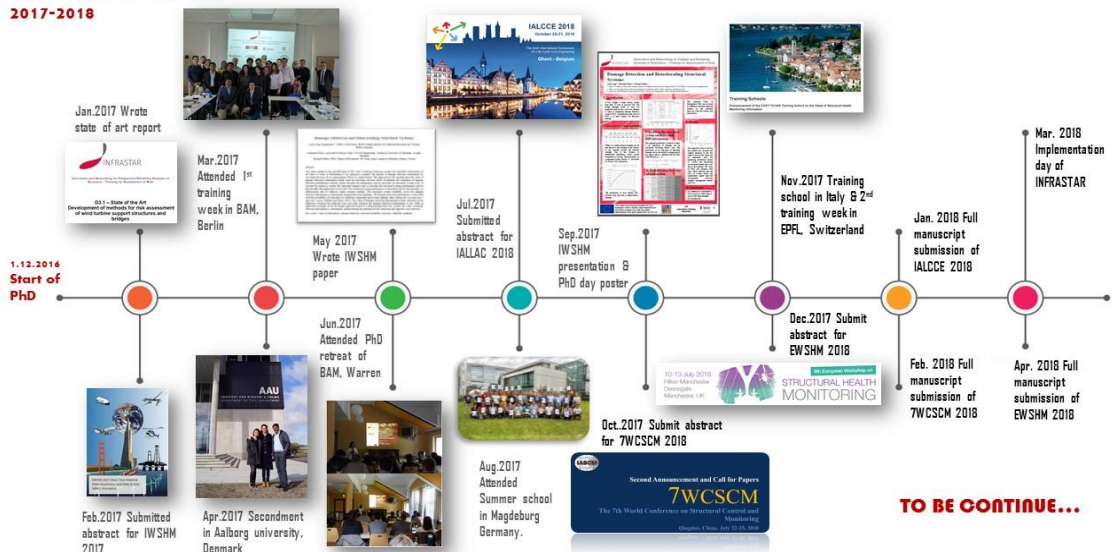
LIST OF PUBLICATIONS

- **Long-term cyclic triaxial tests with DEM simulations**
  G. Zorzi, F. Kirsch, F. Gabrieli, F. Rackwitz
  PARTICLES 2017, V International Conference on Particle-based Methods – Fundamentals and Applications, Hannover, Germany
  26-28 September 2017

- **Damage detection and deteriorating structural systems**
  L. Long, S. Thöns, M. Döhler
  IWSHM 2017, The 11th International Workshop on Structural Health Monitoring, Stanford, California, USA
  12-14 September 2017

- **Extreme effects on bridges caused by traffic and wind**
  M. Nesterova, F. Schmidt, C. Soize, D. Siegert
  CFM 2017, Congrès Français de Mécanique 2017, Lille, France
  28 August - 01 September 2017

VALEMO JOINED THE PROJECT AS A PARTNER ORGANISATION.

VALEMO is a wholly owned subsidiary of VALOREM, which provides three types of services: operation, supervision, and maintenance of renewable energy plants. Today, VALEMO operates about 40 green energy plants, which represents almost 500 MW.

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WHAT'S ON THE INFRASTAR AGENDA?

The second training week is scheduled from the 20th until the 24th of November 2017 at **EPFL** and will address the challenge of the shift from lab to real in situ conditions.

Basic scientific skills:
- Signal processing and inverse problem (IFSTTAR)
- Safety and reliability of structures (EPFL)
- Topical issues of public economy and civil infrastructures (EPFL)

Advanced scientific skills:
- Acquisition devices and sensors (NeoStrain)
- Link between life prediction models and NDT output (IFSTTAR)
- Foundations of wind energy turbines and other large structures (GuD)
- Probabilistic approaches of fatigue of steel and composite structures (IFSTTAR)
- Traffic loads on bridges: measurements (WIM), modelling and use for load effect, strain and stress assessment – POLLUX software (IFSTTAR)
- Advanced methods for reliability analysis of structures (PHIMECA)
- Advanced methods for probabilistic sensitivity analysis (PHIMECA)
- Reliability modelling of wind turbine towers and foundations (AAU)
- Risk analysis and risk-based optimal planning of operation & Maintenance (AAU)

Complementary skills:
- Ethics in research (EPFL)
- Team working and project management

Technical visits:
- Bridge and wind turbine tour (EPFL)

The first implementation day is organised jointly with **BASt**, the German Federal Highway Research Institute, in Berglich Gladbach (Germany), on Tuesday, the 20th of March 2018. The day after (21 March 2018) is the national symposium organised by BASt, and dedicated this year to smart structures.

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.

The preliminary programme includes:
- A keynote on railway structures by Dr. Peter Lippert (Deutsche Bahn, member of the End User Advisory Board).
- Presentations by the INFRASTAR ESRs (experimental NDT/SHM results, joint works on shared objects).
- A poster session and demonstrations.
- A round table: exchanges between industries and academia, challenges and needs related to monitoring and auscultation.

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

Imane (ESR4), Gianluca (ESR7) and Lijia (ESR12) during the "Long night of museums".

Xin (ESR1), Joyraj (ESR3) and Imane (ESR4) getting the data from the BLEIB structure.

Joyraj (ESR3), Xin (ESR1) and Antoine (ESR2) attending a summer school on smart materials and structures.

Joey (ESR8), Amol (ESR9), Sima (ESR11) and Bartłomiej (ESR5) attending a summer school @ DTU.

Imane (ESR4), Mariia (ESR6) and Bartłomiej (ESR5) @ EPFL.

All 12 ESRs at BAM during the first training week.

Technical visit at the Pergamon Museum in Berlin.

INFRASTAR

BREAKING NEWS

Prof. Eugen Brühwiler: "Fatigue does not exist… Our task is to show that there is no fatigue problem".

How?
Fatigue action effect < Fatigue resistance