TRAINING THE NEXT GENERATION

Training the next generation

Associate Professor Arturo González and **Federico Perrotta** highlight the pressing societal and economic need to reduce uncertainty in structural safety, and explain how their Innovative Training Programme is working to achieve this

Arturo González   *Federico Perrotta*

What are the circumstances that have made a network like Training in Reduction Uncertainty in Structural Safety (TRUSS) necessary?

AG: While an efficient infrastructure network provides economic and social benefits, infrastructure failure in terms of capacity or reliability can involve significant economic costs, lower quality of life and, most importantly, loss of lives. Research projects in TRUSS aim to address uncertainties – such as those found in the performance of the racks used to store spent nuclear fuel rods in the cooling pool during the Fukushima nuclear disaster in 2011; the assessment of concrete strength required to prevent collapses, such as the eight-storey Savar building in Dhaka, Bangladesh, in 2013; and methods to detect damage in bridges before failures, such as the one in Minneapolis, US, in 2007 or in Lecco and Camerano, Italy, in the last year, can take place.

What are the specific aims of TRUSS?

AG: The Marie Skłodowska-Curie Innovative Training Programme (ITN) programme

aims to 'train a new generation of creative, entrepreneurial and innovative researchers, able to face current and future challenges and to convert knowledge and ideas into products and services for economic and social benefit'. In the case of TRUSS, this refers to reliable monitoring systems and structural, material and loading models that: (a) contribute to more efficient infrastructure design, assessment, monitoring and management; (b) maintain current infrastructure stock in operation while minimising risks; and (c) reduce infrastructure costs and demand for non-renewable and carbon intensive resources while maintaining or improving safety levels. However, this is a complex task due to uncertainties surrounding structural capacity and the demand on a structure.

Could you outline some of the benefits of completing research under the ITN umbrella?

FP: Speaking as a TRUSS Early Stage Researcher (ESR), I feel that, when compared to any other PhD course or research scheme, completing research under the ITN framework can be an absolute advantage. One major benefit is certainly the possibility of our findings having a huge resonance with the scientific community. Since a significant portion of our funding comes from taxpayers through the EU, the research will be freely accessible and will also have an impact on the general

public. The fact that this programme is funded by the EU will make our results available at a governmental level, and this is an opportunity for raising political awareness regarding the issues that we treat in our studies with a concrete possibility of immediate application. Additionally, the ITN makes our profile highly visible to research institutes and companies worldwide, increasing our chances of future employability.

In what ways do you think the outcomes of this type of research, which are very important to society generally, can be better communicated to the wider public?

FP: Personally, I strongly believe in the potential of the use of social media in research. It is such a powerful tool for communication. Dedicating a minimal amount of time to sharing our thoughts and findings through social media can be one of the key factors for communicating science and research to the wider public successfully. All TRUSS ESRs have multiple social media profiles, and we try to share our achievements and keep the wider public updated using social media. It is so easy – we can simply upload a short post, picture, audio file, or video clip, or link to an interesting piece of work that we find on the Internet or a document, and the contents are instantly accessible to everybody.

Managing Europe's ageing infrastructure

The **Training in Reducing Uncertainty in Structural Safety (TRUSS)** Innovative Training Network is developing tools to better maintain and manage Europe's ageing infrastructure, while also providing valuable training to Early Career Researchers

European infrastructure is extensive and well developed, but much of it is also ageing. Replacing this ageing network is costly, disruptive and time consuming – so it is vital that what is already in place is utilised to its full potential. This scenario is made even more perilous by the reduced spending in maintenance caused by the economic downturn of recent years. As such, a management strategy that guarantees maintenance and structural safety with the best use of the resources available is required.

This goal is at the heart of the TRUSS Innovative Training Network (ITN). TRUSS addresses a lack of expertise on the management and modernisation of an ageing infrastructure stock that is critical for society to function and prosper. The cost of making repairs once an infrastructure starts to fail is prohibitive, yet there is no easy way to measure how infrastructure deteriorates over time and to assess structural safety. Arturo González, TRUSS's project coordinator, explains: 'New concepts and technologies for the manufacturing, monitoring, modelling, testing and reliability analysis of structures are emerging all the time. The TRUSS consortium combines and shares expertise to increase knowledge around structural safety by incorporating

these emerging technologies and innovative algorithms into an advanced training programme at doctoral level beyond the education provided by Bachelor and Masters programmes. In addition to these technical skills, TRUSS supports job creation by enabling a wider talent pool of skilled and accredited engineering graduates with business, entrepreneurship, communication, project management and other transferrable skills'.

EUROPE'S FUTURE EXPERTS

The TRUSS initiative has been running since 2015. It is divided into 14 individual research projects, each of which is under the watchful eye of an ESR. The first cluster of projects focuses on buildings, energy and marine infrastructures, while the second cluster deals with rail and road transport infrastructures. The TRUSS ESRs are empowered to acquire specific vocational skills in technological areas that may be difficult to obtain in their home countries. They are given access to a vast network of professional contacts across Europe which, combined with their practical technical experience, allows them to work both nationally and internationally.

One ESR who has benefitted is Federico Perrotta, a doctoral candidate at the

University of Nottingham, UK. In his research, he is investigating the use of truck sensors for road pavement performance investigation. 'When I found out about TRUSS on the internet, I did not think twice. I applied straightaway,' he explains. 'Now, two years later, I do not regret the choice at all. I have learnt so much and I am proud of the results that I have obtained so far. Plus, I have made so many new friends and have had the possibility to travel around the world. So far, it has been just a fantastic experience.'

PAN-EUROPEAN COLLABORATION

The TRUSS ESRs are spread out across the training network – a consortium comprising six leading European universities, one research institute and eleven industry stakeholders. 'The TRUSS partners come from five European countries and are experts in the fields of infrastructure design, construction and management, structural monitoring, material testing and reliability analysis,' González elaborates. 'Their teams have a multidisciplinary background that include civil, mechanical, chemical and electrical and electronic engineers, mathematicians, computer scientists, and business and marketing managers.' This multidisciplinary training prepares ESRs for a world where an understanding of the perspectives of those from other disciplines is key and will thus increase their adaptability and employability, enhancing their long-term career prospects. The ESRs also benefit from the international nature of TRUSS by spending training periods in different countries that increase intercultural awareness and teach them to meet the challenges that working in another cultural environment presents.

Given the broad range of infrastructure that the project covers and the multidisciplinary and diverse culture of the researchers, there

From left to right: Sofia Antonopoulou (ESR1), Giulia Milana (ESR6), Loreto Manriquez (Project Manager) and Barbara Heitner (ESR8)

António Barrias (ESR11) testing distributed optical fiber sensing system

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was always going to be numerous challenges. 'There was a need to find a common thread that would make our consortium work as a team. Therefore, we hold regular TRUSS training/dissemination events and meetings,' González explains. 'These meetings are divided into two parts. The first part consists of presentations that supply progress updates and gather feedback from the entire network and, for the second part, the network is divided into smaller, more focused working groups, one for each individual research project, that discuss development plans in detail. This arrangement has led to opportunities for secondments, new interactions between researchers, and the generation of innovations that form the basis for new research.'

A BRIGHT FUTURE

By developing tools that will reduce uncertainty in structural safety and improve infrastructure management, the project is meeting a critical need whilst at the same time enhancing the ESRs' career prospects in both industry and academia by matching their skills to the jobs of the future. As Perrotta enthuses: 'For me and the other fellows, this is a massive opportunity. TRUSS gives us the possibility of interacting with some of the most widely recognised professors and experts in engineering, experiencing both academia and industry at the same time. We can undertake trainings in any topic, giving us the chance to shape our personal and professional profile as we really want. We can attend seminars and

conferences regarding the latest technologies used in the field. We can develop soft skills such as critical thinking, problem solving and team working. And it makes us ready for technical writing and presentation of our work to experts, as well as to people outside of our topic. Honestly, this is not just any training or PhD course'.

THE TRUSS PROJECTS

Buildings, energy and marine infrastructure
- **ESR1:** Sofia Antonopoulou (University College Dublin) – Reliability of concrete structures reinforced with braided FRP
- **ESR2:** Md Shah Nur Alam Sourav (Ove Arup & Partners) – Reduction of uncertainty in assessing concrete strength of existing structures
- **ESR3:** Alberto González Merino (Equipos Nucleares SA) – Reduction of uncertainty in design of free standing nuclear spent fuel rack
- **ESR4:** Rui Teixeira (Trinity College Dublin) – Probabilistic optimisation of the design of offshore wind turbine towers
- **ESR5:** Guang Zou (Lloyd's Register EMEA) – A probabilistic framework for fatigue crack management of ship structures
- **ESR6:** Giulia Milana (Lloyd's Register EMEA) – Residual life assessment and management of ship unloaders

Rail and road infrastructure
- **ESR7:** Farhad Huseynov (Full Scale Dynamics Ltd) – Bridge condition assessment using rotation

measurements
- **ESR8:** Barbara Heitner (Phimeca Engineering) – Probabilistic modelling of bridge damage based on damage indicators
- **ESR9:** Matteo Vagnoli (University of Nottingham) – Railway bridge condition monitoring and fault diagnostics
- **ESR10:** John James Moughty (Universitat Politècnica de Catalunya) – Assessment of bridge condition and safety based on measured vibration level
- **ESR11:** António Barrias (Universitat Politècnica de Catalunya) – Development of distributed optical fibre sensing for structural health monitoring of bridges and large-scale structures
- **ESR12:** Daniel Martínez Otero (University College Dublin) – Bridge damage detection using an instrumented vehicle
- **ESR13:** Federico Perrotta (University of Nottingham) – Using truck sensors for road pavement performance investigation
- **ESR14:** Siyuan Chen (University College Dublin) – Reduction of uncertainty through regularized, automated road infrastructure inspection, using unmanned aerial vehicles

Project Insights

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Associate Professor Arturo González graduated as a civil engineer at University of Cantabria, Spain, and obtained MSc and PhD degrees from Trinity College Dublin, Ireland. In 2001, he continued research as Newman Postdoctoral Fellow in University College Dublin, and he has been a college lecturer there since 2003.