DCE23 5th DOCTORAL CONGRESS IN ENGINEERING

Book of Abstracts

DCE23 - Symposium on Civil Engineering

U.PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

DCE 23 5th DOCTORAL CONGRESS IN ENGINEERING

Book of Abstracts

of the

Symposium on Civil Engineering

Editors:
Elsa Caetano, Francisco Pinto,
Gonçalo Ferreira, Lurdes Lopes, Manuel Jesus

Porto
June 2023

OUR SILVER SPONSORS

APDL

ADMINISTRAÇÃO DOS PORTOS
DOURO • LEIXÕES • VIANA

This volume contains the peer reviewed and accepted abstracts, presented at the Symposium on Civil Engineering, of the 5th Doctoral Congress in Engineering – DCE23, held at FEUP-U.Porto, Porto, Portugal, between June 15th and 16th, 2023.

Title: Book of Abstracts of DCE'23 Symposium on Civil Engineering

Edited by Elsa Caetano, Francisco Pinto, Gonçalo Ferreira, Lurdes Lopes, Manuel Jesus

Published by: FEUP Edições

Digital version Symposium on Civil Engineering – DCE 2023 (up.pt)

First edition June 2023

ISBN. 978-972-752-313-9

OUR BRONZE SPONSORS

WELCOME

Welcome Address

The 5th Doctoral Congress in Engineering (DCE) will be held on the 15th and 16th of June 2023 at the Faculty of Engineering of the University of Porto (FEUP) in Porto, Portugal.

DCE 23 is the fifth edition of a conference in engineering organized by FEUP, comprehending a series of plenary sessions (Keynote lectures, oral presentations and posters) and a series of parallel symposia on the different areas of engineering.

A distinct characteristic of DCE is its organization's wide intervention of doctoral students. For the symposium on Civil Engineering, the contribution of Francisco Pinto, Gonçalo Ferreira, and Manuel Jesus has been crucial. Together with the scientific commission, our researchers have created an exciting program which gathers the contributions of about fifty papers in the different areas of civil engineering: Structures, Construction, Hydraulics, Materials, Geotechnics, and Transport Infrastructures. Thirty of these contributions will be presented orally during three sessions, and twenty will be presented in a poster session. The sessions will be initiated by three Keynote lectures in the areas most represented in PRODEC: Dr Pedro Museros, from the Polytechnic University of Valencia, will deliver a speech on dynamics and railways structures; Dr Nuno Simões, from the University of Coimbra, will focus on Constructions; Prof. Henrique Pena will talk about Artificial Intelligence applied to the management of ports.

On behalf of the Doctoral Program in Civil Engineering (PRODEC) and with Prof. Lurdes Costa, I want to invite you to participate in this conference and use this opportunity to establish collaborations and personal links with our research community. Most of all, we hope you will enjoy these two days of interaction.

Elsa Caetano

Lurdes Costa

Chairs of Organizing Committee

CONTENTS

Contents

COMMITTEES

Organizing Committee

Chair: Elsa Caetano | FEUP

Chair: Lurdes Lopes | FEUP

Francisco Pinto | FEUP

Gonçalo Ferreira | FEUP

Manuel Jesus | FEUP

Scientific Committee

Aires Colaço

Alexandre Pinto

Ana Mafalda Matos

Ana Margarida Bento

Ana Ramos

Ana Sofia Guimarães

António Lobo

Bárbara Rangel

Carlos Sousa

Castorina Vieira

Cecília Vale

Cláudio Horas

Cristiana Ferreira

Daniel Clemente

Diogo Ribeiro

Elsa Caetano

Fernanda Bessa

Filipe Magalhães

Gianmaria Giannini

Joana Maia

João Delgado

Juliana Mendes

Lino Maia

Luciana das Neves

Lurdes Lopes

Miguel Ferraz

Pedro Montenegro

Pedro Pereira

Ricardo Carneiro

Sara Ferreira

Sara Rios

Tiago Ferradosa

Symposium Programme – June 15th

15:00 | Room B020

Session Chairs: Lurdes Lopes, Pedro Montenegro

- **Keynote lecture** Professor Pedro Museros (Department of Continuum Mechanics and Theory of Structures, Universitat Politècnica de València). *Opportunities for Bridge Dynamics in research and practice within the scope of Railway Engineering*.
- Francisco Pimenta. *The roll of physics-motivated analytical models in the development of new monitoring strategies for floating wind turbines*. [163]
- Filipe Miranda, Alexandre Carvalho, Ana Margarida Bento, Paulo Rosa-Santos, Francisco Taveira Pinto, Tiago Ferradosa. *Investigation on wave attenuation in offshore aquaculture systems*. [233]
- Tassia Latorraca. *3D Printing for Construcion: Exploring the Performance of Industrialized Thermal Cob Mix for Sustainable Building Envelope*. [93]
- Fausto Molina-Gómez, António Viana da Fonseca, Cristiana Ferreira, Bernardo Caicedo. *Mitigation of earthquake-induced liquefaction by induced partial saturation in sands*. [301]
- Orlando Lima Jr., Iran Rocha Segundo, Laura Mazzoni, Elisabete F. Freitas, Joaquim Carneiro. *Smart Road Markings: Anti-Aging, Photoluminescence, Self-Cleaning, and Thermochromism*. [225]
- Artur Silva, Diogo Ribeiro, Pedro A. Montenegro, Andreia Meixedo, Rui Calçada. *Machine learning methodologies for damage identification in railway bridges*. [148]
- Pedro A. C. Lombe. *Drought characterization in southern Angola*. [36]

17:00 | Room B020

Session Chairs: Ana Margarida Bento, Cláudio Horas

- **Keynote lecture** Professor Nuno Simões (Associate Professor of the University of Coimbra | Senior Scientific and Technical Researcher at Itecons). *Research experience: Overview of the performance of external vacuum insulation composite system*.
- Luís Jacques de Sousa, João Poças Martins, Luís Sanhudo. *Framework for the Automation of Construction Task Matching from Bills of Quantities using Natural Language Processing*. [8]
- Rui M. Valente, Carlos F. Sousa, José Rui Pinto. *Hybrid precast railway bridge using HPFRC and UHPFRC*. [159]
- Sérgio R. T. Salgado, Elsa Carvalho, Teresa Viseu, Othon Oliveira. *Assessing the Impact of Topographical Data and Flood Map Elaboration Models on Dam Safety Classification: A Case Study in Pernambuco, Brazil*. [133]
- Cyrus Eshaghi. *Investigating the Effect of Manufacturing Tolerances on the Flexural Cyclic Behavior of I-Shaped Hot Rolled Steel Beams*. [299]
- Tiago Ferradosa, Lino Monteiro, Filipe Miranda, Cristiana Ferreira, Francisco Taveira Pinto. *Experimental study on scour around underwater pipelines*. [234]
- Diogo F. R. Parracho, João Poças Martins. *idBIM4.0 – National Library of BIM Objects: The Railway*. [22]

- Filipe Almeida, Castorina S. Vieira, Nuno Cristelo, Ana Fernández-Jiménez, Maria de Lurdes Lopes. Hybrid alkaline cements: a feasible alternative to Portland cement [289]

Symposium Programme – June 16th

9:00 | Room B020

Session Chairs: Ana Matos, Fernanda Ferreira

- **Keynote lecture** Professor Enrique Peña (Water and Environmental Engineering Group, University of A Coruña (Spain)). *Artificial Intelligence - based Decision-Making Tools for Port Management: Moored ship behavior and Overtopping predictive models*.
- Idilson António Nhamage. *Development of a Digital Twin model for fatigue assessment of railway steel bridges*. [165]
- João Arrojado. *Strengthening Ancient Metallic Bridges: theoretical overview of Retrofitting Techniques based on Fatigue and Fracture Mechanics approaches*. [220]
- Ajab Gul Majidi, Victor Ramos, Paulo Rosa Santos, Luciana das Neves, Francisco Taveira Pinto. *Seasonal Variability in Wave Resources for the Atlantic Iberian Peninsula Coast under RCP8.5 Climate Change Scenario by the End of 21st Century*. [54]
- Pedro Mêda. *Bills of Data, conceptualizing the construction 4.0 version of Bills of Quantities*. [272]
- Rafael Cabral, Diogo Ribeiro, José Correia. *Enhancing Railway Bridge Inspection and Monitoring with Computer Vision*. [214]
- Isabela Basto, Juliana M. Mendes, Rodrigo Maia. *Flood Forecasting using Machine Learning Techniques: Application In A Section Of The Minho River Basin*. [132]

11:00 | Room B020

Session Chairs: António Lobo, Daniel Clemente

- Ahmad Q. Almomani, Eva Barreira, Ricardo Almeida. *A critical review of energy retrofitting trends in residential buildings with a particular focus on Jordan*. [263]
- Rui M Sousa, Hipolito Sousa, Humberto Varum. *Masonry partition walls affected by de vertical deflection of structural elements – A Review*. [290]
- José Eduardo Barros. *Towards an innovative approach for assessing coastal flooding extension: a Case Study on the Northern Portuguese coast*. [157]
- Marco António Peixer M. António, Pedro A. Montenegro, Rui Calçada. *Evaluation Of Train-Structure Interaction Using A Railway Bridge Dynamic Model*. [164]
- Justino Costa Soares, Paulo Santos, Tiago Ferradosa, Mahdi Alemi, Ana Margarida Bento. *Drought monitoring and assessment using the standardized precipitation index in four different sites in Timor-Leste*. [192]
- Mohammadreza Mohammadi, Araliya Mosleh, Cecília Maria Nogueira Alvarenga Santos do Vale, Diogo Ribeiro, Pedro A. Montenegro, Andreia Meixedo. *A machine learning approach for detection of railway wheel flats using track-side monitoring*. [105]
- Cynthia Mac-Beath de los Reyes. *Sustainable Drainage Systems: a solution for rainwater drainage in Luanda, Angola*. [291]
- Gabriel G. Hojda. *Bidirectional seismic fragility functions for RC structures. State-of-the-art: a closeness to reality.* [169]
- Leticia C. M. Dafico. *Identifying the moisture content in building materials using machine learning models*. [298]
- Nelson Traquinho, Rui Calçada, Diogo Ribeiro. *Enhanced Algorithms for Damages Detection on Railway Vehicle*-Track-*Cable Stayed Bridges Dynamic Systems based on Data Science: A literature Review*. [147]

- Bogdan I. Gheorghe. *Seismic risk assessment for the residential building stock for Bucharest with application in the insurance system*. [231]
- Reihane Shafie Panah, Humberto Varum, José Melo, Vítor Silva. *Damage detection of reinforced concrete structures based on period elongation*. [275]

13:00

Poster session jury: Ana Ramos, Juliana Mendes

List of the Symposium Keynote Speakers

Professor Pedro Museros, *Department of Continuum Mechanics and Theory of Structures, Universitat Politècnica de València.*

Topic: Opportunities for Bridge Dynamics in research and practice within the scope of Railway Engineering.

Pedro Museros (Madrid, 1971) has been an associate professor at the Polytechnic University of Valencia (UPV) since December 2010. He was previously a professor at the University of Granada and University Jaume I of Castellón. He obtained his PhD at the Polytechnic University of Madrid in 2002, entitled "Vehicle-Bridge Interaction and Resonance Effects in Simply-supported Railway Bridges for High Speed Lines". He is a member of the Editorial board of the Int. Journal of Structural Stability and Dynamics, and belongs to the "Fundación Caminos de Hierro" for railway research and engineering (FCH). He has published 28 contributions in the Web of Science and 41 publications in Scopus (ORCID: 0000-0002-1389-0204; RESEARCHER ID: L-2478-2017): 704 total citations; 50 cites/year in the last 5 years. He has supervised 3 PhD theses in the field of railway bridge dynamics, and been the principal researcher in several national projects funded by the Spanish Government and private entities.

Professor Nuno Simões, *Associate Professor of the University of Coimbra | Senior Scientific and Technical Researcher at Itecons.*

Topic: Research experience: Overview of the performance of external vacuum insulation composite system.

Nuno Simões (PhD in Civil Engineering), Assistant Professor at the Department of Civil Engineering, University of Coimbra and Senior Scientific and Technical Researcher of IteCons; he has published more than 70 papers in indexed scientific international journals and participated in more than 170 communications in conferences. He has participated in more than 27 funded research projects (13 as PI). He has supervised 6 PhD thesis and is supervising 6 others in progress. He has supervised more than 55 Master thesis. Member of CERIS - Civil Engineering Research and Innovation for Sustainability.

Professor Enrique Peña, *Full Professor of the University of A Coruña (Spain)*

Topic: Artificial Intelligence - based Decision-Making Tools for Port Management: Moored ship behavior and Overtopping predictive models

Professor in the University of A Coruña since 1997, becoming Full Professor in 2019. Development and leadership of the Water and Environmental Engineering Group GEAMA. Director of the Port and Maritime Facilities in the CITEEC R&D Centre. Publications: 60 (Scopus database) and more than 100 in International Conferences, such as ICCE, PIANC, OMAE, ICE. Supervisor of 8 PhD students. Projects: more than 115 competitive and R&D contracts with mainly applied research and technology transfer in coastal engineering.

Oral Communications presented in the Symposium

Framework for the Automation of Construction Task Matching from Bills of Quantities using Natural Language Processing

Luís Jacques de Sousa[1], João Poças Martins[1], Luís Sanhudo[2]

1FEUP

2BUILT CoLAB

Abstract

During the budgeting stage of construction processes, construction companies must assess each task's scope from the Bill of Quantities (BoQ) and map them individually to an internal database. When non-standard BoQs are used, the mapping process is highly dependent on human judgement, as each task is interpreted individually based on its description, classification code and other text elements, besides drawings and BIM models. Even though this assessment influences companies' bid quality, surveyors carry it out manually with almost no automation.

In this sense, a methodology and framework for developing and implementing a Natural Language Processing (NLP) task-matching algorithm are presented. This study sets out to develop datasets that represent a variety of tasks in Construction, build an algorithm capable of task matching across different disciplines, and reduce the need for expert validation of the matching results. Furthermore, the implementation framework structures the algorithm in the procurement workflow and drives future developments.

Author Keywords. Machine Learning, Natural Language Processing, Construction Procurement, Automatic Classification of Construction Tasks

ID: 8

idBIM4.0 – National Library of BIM Objects: The Railway

Diogo F. R. Parracho[1], João Poças Martins[2,3]

[1]CONSTRUCT-GEQUALTEC, Civil Engineering Department, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (dfrparracho@fe.up.pt) ORCID 0000-0003-0413-6178

[2]CONSTRUCT-GEQUALTEC, Civil Engineering Department, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (jppm@fe.up.pt) ORCID 0000-0001-9878-3792

[3]Built CoLAB – Collaborative Laboratory for the Future Built Environment, Rua do Campo Alegre 760, 4150-003, Porto, Portugal.

Abstract

The Mobilizing Project "Digital Construction Revolution – REV@CONSTRUCTION" focuses on the Digital Transition, aiming to increase productivity, competitiveness, and sustainable growth of the Portuguese AEC sector through different R&D activities. One of these activities is creating and developing a national standardized library of BIM objects (idBIM4.0), aligned with the international normative documents. As such, this paper presents the approach to developing railway BIM objects and their respective Product Data Templates (PDTs).

Author Keywords. idBIM4.0, The Portuguese BIM Library, REV@CONSTRUCTION, DIGI4Construction, Product Data Template (PDT), Railway 4.0

ID: 22

Has Drought in Angola intensified because of Climate Change?

Pedro Anastásio Cumena Lombe[1], Elsa Maria da Silva Carvalho[1],

Paulo Jorge Rosa Santos[1]

[1]Faculty of Engineering of the University of Porto, Porto, Portugal

up201407072@edu.fe.up.pt; elsac@fe.up.pt; pjrsantos@fe.up.pt

Abstract

This study has investigated the impact of climate change on the occurrence of drought events in Angola. With extreme weather events on the rise globally, the Southern Africa region, including Angola, has been identified as one of the most affected areas in terms of rising temperatures, according to the Intergovernmental Panel on Climate Change (IPCC, 2014). By analyzing a 40-year dataset encompassing drought events, average precipitation, and maximum and minimum temperatures, the study examined the relationship between climate change and the intensification of drought in Angola. Our findings reveal a clear influence of climate change on the increased magnitude and frequency of drought events in the country. Notably, rising temperatures were observed, while precipitation exhibited a declining trend.

Author Keywords. drought, climate change, Angola, precipitation patterns, temperature trends, drought severity indices.

ID: 36

Seasonal Variability in Wave Power Resource on the Atlantic Iberian Peninsula Coast under RCP8.5 Climate Change Scenario

Ajab Gul Majidi[1,2], Victor Ramos[1,2], Paulo Rosa Santos[1,2], Luciana das Neves[1,2,3], Francisco Taveira-Pinto[1,2]

[1]Department of Civil Engineering, Faculty of Engineering of the University of Porto (FEUP), Rua Dr. Roberto Frias, S/N, 4200-465 Porto, Portugal (ajabgulmajidi@gmail.com, jvrc@fe.up.pt, pjrsantos@fe.up.pt, lpneves@fe.up.pt, fpinto@fe.up.pt; ORCIDs: 0000-0003-0006-5843, 0000-0001-5507-0995, 0000-0002-3768-3314, 0000-0002-7876-6423, 0000-0003-4337-8428)

[2]Interdisciplinary Centre of Marine and Environmental Research of the University of Porto (CIIMAR), Avenida General Norton de Matos, S/N, 4450-208 Matosinhos, Portugal.

[3]IMDC—International Marine and Dredging Consultants, Van Immerseelstraat 66, 2018 Antwerp, Belgium.

Abstract

Climate change is anticipated to have a considerable impact on the wave climate of coastal regions around the globe, which could result in major repercussions for coastal infrastructure and communities. As a result, it is critical to understand how the wave climate will change in the future and establish adaptation strategies to mitigate potential impacts. This research utilized the SWAN (Simulating WAves Nearshore) to assess the seasonal changes in wave climate on the Atlantic coast of the Iberian Peninsula under the high-emissions climate change scenario (Representative Concentration Pathway, RCP8.5). The model was initially forced with ERA5 wind and wave reanalysis and then calibrated using the SWAN ST6 physics and validated against observations in 10 different locations across the study area. Later, the model run included two different time periods: 1979-1998 in the past and 2081-2100 in the future. Finally, the mean seasonal spatial data was compared in the present study.

The findings indicated that wave climate vary seasonally and spatially, and hence can have significant implications for harvesting ocean wave energy. In the spring season, the study revealed that the maximum decrease in the significant wave height (Hm0) was 0.36 m in the coastal area of Galicia, Spain, and the maximum decrease in wave power (Pw) was 20.86 kW/m in the northwest corner of the study domain. However, the spatial mean Hm0 and Pw decreased by 0.19 m and 6.72 kW/m, respectively. In the summer season, the research found that the maximum Hm0 decreased by 0.22 m close to the Cádiz port in Spain, while the maximum increase of Pw was 2.57 kW/m in the southwestern. The spatial mean Hm0 and Pw decreased by 0.03 m and 0.32 kW/m, respectively. This implies that the summer season could become less favorable for wave energy extraction in the coastal area near the Cádiz port but may become more favorable for wave energy generation in the southwestern area. In the autumn season, the maximum Hm0 decrease was 0.29 m in the northwest, and the maximum Pw decreased by 10.81 kW/m in the northwestern area of the study domain. However, the spatial mean Hm0 and Pw decreased by 0.17 m and 4.82 kW/m, respectively. In the winter season, the maximum Hm0 decreased by 0.35 m, and the maximum Pw decreased by 26.97 kW/m in the northwest corner of the study domain. Nevertheless, the spatial mean Hm0 decreased by 0.10 m, and the spatial mean Pw decreased by 6.93 kW/m.

In summary, the findings indicate that the spring, summer, autumn, and winter seasons could become less favorable for wave energy generation in some areas, while other areas may become more favorable for wave energy extraction, highlighting the importance of considering the seasonal variability of wave climate. Further research that considers both mean and extreme wave conditions and other relevant factors are necessary to inform the development of adaptation strategies and the design of coastal structures and wave energy converters.

Author Keywords. Wave Climate, Wave energy, Adaptation Strategies, SWAN. *ID: 54*

Thermal Mortar for 3D-Printed Building Walls: A Comprehensive Research Proposal

Tassia Latorraca[1]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (tassialatorraca@gmail.com) ORCID 0000-0002-9327-3715

Abstract

This short paper presents a research proposal to investigate the thermal behavior of 3D-printed building walls and develop design strategies to enhance their thermal performance. The study addresses the factors influencing heat and moisture properties, analyzes thermal behavior using advanced techniques, and explores customized design approaches. By conducting comprehensive research in these areas, the proposed project aims to contribute to the understanding and enhancement of the thermal performance of 3D-printed building walls. The findings will provide valuable insights for designers, engineers, and researchers involved in developing and implementing 3D-printed construction technology, promoting energy efficiency and sustainability in the construction industry.

Author Keywords. 3D Printing, Building Construction, Thermal Comfort, Energy Efficiency, Computational Modeling, Sustainability

ID: 93

A machine learning approach for detection of railway wheel flats using track-side monitoring

Mohammadreza Mohammadi[1], Araliya Mosleh[2], Cecilia Vale[3], Diogo Ribeiro[4], Pedro Montenegro[5], Andreia Meixedo[6]

[1]CONSTRUCT – LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202202392@edu.fe.up.pt) ORCID 0000-0003-1079-4687

[2]CONSTRUCT – LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (amosleh@fe.up.pt) ORCID 0000-0001-6751-0388

[3]CONSTRUCT – LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cvale@fe.up.pt) ORCID 0000-0003-2470-9834

[4]CONSTRUCT, School of Engineering, Polytechnic of Porto, 4249-015 Porto, (drr@isep.ipp.pt) ORCID 0000-0001-8624-9904

[5]CONSTRUCT – LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (paires@fe.up.pt) ORCID 0000-0001-5699-4428

[6]CONSTRUCT – LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ameixedo@fe.up.pt) ORCID 0000-0001-8327-1452

Abstract

Maintaining and repairing wheels on freight vehicles can be expensive and time-consuming, particularly when damage occurs. One of the most common types of wheel damage is wheel flat, which can cause further damage to track components and increase the likelihood of failure. This paper aims to propose an unsupervised damage detection methodology capable of automatically distinguishing between healthy and defective wheels, even when the defect is small. The proposed methodology is based on the measurement of the acceleration during the passage of freight vehicles. The present study includes five steps: (i) Data acquisition from sensors on the rail. These sensors record the rail acceleration, which is a proxy for the vehicle's motion and the wheel conditions; (ii) Feature extraction is implemented to extract damage-sensitive features from acquired data using the Autoregressive (AR) model. This method is commonly used in signal processing and is particularly useful for time-series data such as rail acceleration; (iii) Feature normalization is performed based on a latent variable method. The principal component analysis (PCA) is used to eliminate environmental and operational effects that may be present in the evaluated acceleration signal; (iv) Data fusion is used to merge features from each sensor to enhance the sensitivity to damage. For this purpose, Mahalanobis distance (MD) is employed to achieve a damage index (DI) for each simulation; (v) finally, outlier analysis is performed to monitor wheel condition using confidence boundary (CB). A Gaussian inverse cumulative distribution function is used to estimate a CB for detecting an outlier DI.

The result of the present study demonstrated that a single sensor on the rail is sufficient to detect a defective wheel. Additionally, the AR method demonstrated the potential to distinguish between defective wheels on the left and right sides. The unsupervised early damage detection methodology presented in this paper has the potential to significantly reduce maintenance costs and improve the safety and reliability of freight vehicles.

Author Keywords. wheel flat detection; wayside condition monitoring; train-track interaction; unsupervised learning.

ID: 105

Flood forecasting using machine learning techniques: application in a section of the Minho River basin

Isabela Basto[1], Juliana Mendes[2], Rodrigo Maia[3]

[1,2,3]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal.

[1,2,3]CIIMAR-Centro Interdisciplinar de Investigação Marinha e Ambiental, Terminal de Cruzeiros do Porto de Leixões, Matosinhos, Portugal

[1]up201909364@edu.fe.up.pt (ORCID: 0000-0002-6652-2309),

[2]juliana@fe.up.pt (ORCID: 0000-0003-1843-1434),

[3]rmaia@fe.up.pt (ORCID: 0000-0002-3740-5269)

Abstract

Machine-learning (ML) architectures have been an alternative tool to traditional methods in predicting hydrological variables, which would be valuable to test and evaluate these techniques in the field of flood forecasting in regularized basins. Thus, this study aims to apply ML techniques for flood prediction in a section of the Minho basin. The adopted approach carried out two different applications: (1) streamflow forecasting in a river section without the effect of reservoir operation; (2) reservoir outflows forecasting. As a result, one of the applied architectures (LSTM) presented good performance rates in all simulations, evidencing that the technique would be suitable for a flood forecasting system. However, the presented simulations considered only one future time step. From a practical perspective, it is necessary to design a forecasting system with projections considering more time steps ahead, to obtain an adequate lead time to alert the authorities and the population of the occurrence of a flood event.

Author Keywords. Flood Forecasting; Reservoir outflows forecasting; Long short-term memory; Minho river basin.

ID: 132

Assessing the Impact of Topographical Data and Inundation Map Elaboration Models on Dam Safety Classification: A Case Study in Pernambuco, Brazil

Sérgio Ricardo Toledo Salgado[1], Elsa Maria da Silva Carvalho[2], Maria Teresa Viseu[3] e Othon Fialho de Oliveira[4]

[1]Doctoral Program in Civil Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202001034@fe.up.pt) ORCID 0000-0002-3214-3108

[2]Assistant Professor at the Faculty of Engineering of the University of Porto, Department of Civil Engineering Rua Dr. Roberto Frias, 4200-465, Porto, Portugal (elsac@fe.up.pt) ORCID 0000-0003-2210-249X

[3]Research Assistant at National Laboratory of Civil Engineering (LNEC), Lisboa, Portugal, (tviseu@lnec.pt) ORCID 0000-0001-7332-8136

[4]Doctoral Program in Civil Engineering, Federal University of Pernambuco, Recife-PE, Brazil. (othonfialho@yahoo.com.br)

Abstract

The classification of dams in Brazil is crucial for the National Dam Safety Policy (PNSB), but the accuracy of the classification can be influenced by poor topographic data and the use of simplified methods to determine inundation areas. The National Water Agency (ANA) introduced a simplified methodology based on dam`s height, reservoir`s volume, and location data, using the Shuttle Radar Topography Mission (SRTM) as Digital Elevation Model (DEM). However, this method can generate larger inundation areas compared to more accurate hydraulic models and topography data. A case study was conducted on the Copiti dam, comparing results obtained from the simplified method, HEC-RAS model with SRTM and HEC-RAS model with the PE3D DEM. The simulations showed that the simplified method tends to generate larger inundation areas, while HEC-RAS resulted in smaller areas. The choice of DEM and simulation model significantly impacted the distribution of the population affected by the inundation. The study highlighted the importance of topographic data quality and inundation mapping models in analyzing downstream impacts and the classification of dams.

Author Keywords. hazard classification, inundation maps, digital elevation model

ID: 133

Enhanced Algorithms for Damage Detection on Railway Cable-Stayed Bridges based: A literature Review

Nelson Traquinho[1], Cecília Vale[2], Diogo Ribeiro[3], Rui Calçada[4]

[1,,3,4]Department of Civil Engineering, Faculty of Engineering, University of Port, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[2]Higher Institute of Engineering of Porto (ISEP), Rua Dr. António Bernardino de Almeida, 431

4249-015 Porto, Portugal

Correspondence: up202000086@edu.fe.up.pt

Abstract

When a railway in-service vehicle crosses a railway cable-stayed bridge (with multiple inclined cables), a significant number of dynamic responses (big data) from each of the cables, track components, and or bridge structural elements are obtained. Furthermore, cables are more susceptible to environmental, including temperature effects, which may skew the conclusions about the behavior of the structure. On the other hand, carrying out a vehicle-track-bridge experimental test is of great significance for reproducing these dynamic responses and assessing the damage performance of structures. But may lead to high-cost consumption of physical prototypes or labor. Furthermore, to ensure the testability and conduct a wayside dynamic monitoring, previous numerical modeling is needed, to find the most critical elements, simplify the numerical model (for later calibration) and save the computer efforts, during the modeling process. To perform the numerical modeling or virtual test, data are needed, from previous existing structures (experience) or needs to be generated. Herein, is where data science, data-driven and model-based makes part of structural engineering. Moreover, when dealing with structures with a great number of degrees of freedom, many results (big data) are obtained that need to be compressed and interpreted for decision-makers, using enhanced automated algorithms. Therefore, in this document a review of existing algorithms for the prediction or assessment of railway cable-stayed bridges is discussed, to contribute to damage detection. From the surveyed literatures, it was found that the genetic algorithms and the algorithms based on data mining have great potential in the damage identification of railway cable-stayed bridges with multi-degree of freedom. So, further investigation to test the effectiveness of these algorithms would contribute to early damage detection of railway vehicle-track-cable stayed bridges, using accelerations signals recorded from a wayside monitoring system attached on railway track and on bridge.

Author Keywords. Data-driven structural damages detection, data science, numerical modeling of railway vehicle-track-cable-stayed bridges, signal processing.

ID: 147

Machine learning methodologies for damage identification in railway bridges

Artur Silva[1], Diogo Ribeiro[2], Pedro Montenegro[3], Andreia Meixedo[4], Rui Calçada[5]

[1]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ajpsilva@fe.up.pt) ORCID 0000-0003-4898-6844

[2]CONSTRUCT-LESE, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida, 431, 4249-015 Porto, Portugal (drr@isep.ipp.pt) ORCID 0000-0001-8624-9904

[3]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (paires@fe.up.pt) ORCID 0000-0001-5699-4428

[4]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ameixedo@fe.up.pt) ORCID 0000-0001-8327-1452

[5]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruiabc@fe.up.pt) ORCID 0000-0002-2375-7685

Abstract

In recent years, the railway has emerged as a crucial mode of transportation due to its efficiency and low greenhouse gas emissions. With an increase in the use of railways, the transportation infrastructure has become more reliant on railway bridges. These bridges play a vital role in maintaining the safety and reliability of the railway system, and it is important to ensure their proper maintenance and inspection to extend their lifespan and reduce costs. Structural Health Monitoring (SHM) techniques have been developed to detect damages in railway bridges, with the aim of improving their safety and longevity while reducing inspection and maintenance costs. The implementation of SHM techniques is essential for ensuring the safe use of railway bridges and maintaining their structural integrity.

The present work focuses on the application of machine learning methods to identify damage in a filler-beam railway bridge through numerical simulations. To develop these simulations, advanced finite element (FE) numerical models of train and bridge, including the track, were developed. Dynamic analyses were conducted using the train-bridge dynamic interaction method, which considered the irregularities of the railway track and evaluated both the baseline and damage scenarios of the bridge. The acceleration data from passing trains was used to extract features from the dynamic analysis using Autoregressive models (AR) and Principal Component Analysis (PCA). The classification methodologies were then used to identify the most sensitive features for damage detection. The proposed method can detect early levels of damage without interfering with the normal operation of the train and bridge service.

Author Keywords. Railway bridges, Structural Health Monitoring, Train-bridge dynamic interaction, Damage identification, Autoregressive models, Principal Component Analysis, Classification.

ID: 148

Towards an innovative approach for coastal flooding mapping: a Case Study on the Northern Portuguese coast.

Jose Eduardo Carneiro Barros[1,2], Tiago Ferradosa[1,2], Paulo Rosa Santos[1,2], Francisco Taveira Pinto[1,2]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202204079@edu.fe.up.pt) ORCID 0000-0002-6458-8996

[2]Interdisciplinary Centre of Marine and Environmental Research (CIIMAR), Avenida General Norton de Matos, S/N, 4450-208 Matosinhos, Portugal.xxxxxxxx

Abstract

The Portuguese coast has one of the most energetic wave climates in the world, and it also faces intense anthropic pressure in the coastal zone, with its main public and private infrastructures located in these areas, as well as housing about 75% of the Portuguese population. As a consequence, it has been suffering from systematic coastal flooding episodes at several spots, with an increasing trend being observed in recent decades. Predicting the magnitude of floods accurately is critical for effective coastal management and risk reduction.

In this study, we propose an innovative approach for assessing wave-induced coastal flooding extension by coupling two widely used numerical models, SWASH and LISFLOOD. SWASH is a wave-flow model based on a Non-Linear Shallow Water equation with non-hydrostatic pressure terms, and in this case in a 1D mode (flume-like), while LISFLOOD is a grid-based hydrological model that can distribute volumes of water on a topography, normally related to either rainfall or rivers but in this case, the discharges were extracted from the wave overtopping results from SWASH.

The proposed approach is applied to a case study on the Northern Portuguese coast, at Furadouro Beach, in the municipality of Ovar, which has been facing multiple flooding episodes throughout recent years, including a dramatic storm in February 2014. This event was used as validation for the proposed method, while an extreme values analysis was conducted by a Peaks Over Threshold and a bi-variate extreme values fit of significant wave height (Hs) and peak period (Tp), with expected combined values for different return periods.

This study uses a Digital Terrain Model (DTM) with a resolution of 2m from a LIDAR survey obtained through the Diretorio Nacional do Territorio (DGT) as the topography domain for LISFLOOD, while a 30cm Digital Elevation Model (DEM) was obtained through the “COSMO” Program, that it was used for the foreshore and profile extraction for the SWASH domain. Sea-level measurements were obtained from in situ equipment in a port nearby. An hourly offshore wave dataset from 1990 to 2020, extracted from the ECMWF database at 41.00° N, 9.50° W, as well as propagated sea-states with the SWAN model at 40.81°N 8.73° W were used as wave climate source, while some representative sea-states were used as a boundary condition for the SWASH model. The final outputs from LISFLOOD were post-processed with the QGIS software, overlaying the expected flooded area with satellite imagery.

Results suggest that this can be a powerful tool to predict areas vulnerable to coastal flooding, as it is based on the results of a state-of-the-art physics-based model. In this case, for the validation event of 2014, the results represented an appropriate fit in terms of the affected area when compared to the Municipality’s reported damaged area. This approach has also a significant advantage over physical models in terms of simplicity of implementation, while it also presents several advantages when compared to existing simple GIS-based approaches such as the bathtub approach, which tends to cause significant overestimation.

Author Keywords. SWASH; LISFLOOD; Wave Overtopping; Numerical Models; Coastal Flooding.

ID: 157

Hybrid precast railway bridge using HPFRC and UHPFRC

Rui Valente[1], Mário Pimentel[2], Carlos Sousa[3], José Rui Pinto[4]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201206018@fe.up.pt)

[2]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (mjsp@fe.up.pt)

[3]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cfsousa@fe.up.pt)

[4]Mota-Engil, Engenharia e Construção S.A., Portugal (Jose.R.Pinto@mota-engil.pt)

Abstract

The railway traffic is becoming faster and heavier as a consequence of todays' society needs. Cost-efficient, sustainable and reliable high-capacity infrastructures are required as a result. Bridges in high-speed railway networks need to attend to these demands as well. For these reasons, railway bridges, when compared to highway bridges, are more robust and structural elements tend to be produced on construction site in most cases. The industrialization of construction sector can be possible resorting to off-site construction where structural elements are produced in factory and assembled on construction site. That reduces the construction time and manpower requirements, which is important to control expenses related to the growing labour costs. Precast production of railway bridges would have a boost if structural elements are lighter.

The arise of new improved cementitious composites with higher durability and strength opens a new range of possibilities for structural design concepts and construction of new infrastructure. They allow the design of lighter structural elements, which is particularly advantageous for precast structural systems. Additionally, when these materials use steel fibres, substantial quantities of steel reinforcements can be replaced leading to non-intensive labour solutions for the structural elements.

A continuous deck composed by eight HPFRC precast T-shape girders with a cast-in-place slab is designed for spans up to 35 m. A thin and variable web thickness is adopted. Conventional concrete is used for the slab with exception of the connection zone where the continuity in the hogging moment region is materialized by UHPFRC and rebars. This yielded a reasonable solution in terms of reinforcement ratio and effectively solves problems related to crack widths without requiring post-tensioning continuity tendons.

The T-shaped longitudinal girders in HPFRC allow the construction of lighter elements, which is particularly advantageous for precast solutions where transportation and placement costs are significant and can thus be reduced. Moreover, the rational use of these materials is expected to reduce drastically the demand for passive reinforcement. Economic benefits from reduction of construction complexity, time, and labour help achieving a competitive solution.

Different modelling strategies are used to simulate the global structural behaviour to different actions. One model is used for simulating staged construction and time-dependent effects. Other model is used for assessment of the effects of rail traffic loads, including dynamic analysis using high-speed load models. A tool was developed for the flexural design of hybrid sections using fibre reinforced cementitious composites. Structural limit states relevant for railway bridges are checked as well as track safety and passenger comfort

Considering the possibilities provided by such high-performance materials, comparative studies should be carried out to assess the economic viability of structures using (ultra-)high performance cementitious composites when compared to an equivalent regular concrete structure with equivalent structural performance. The economic advantage of the proposed solution has to come

from reducing substantially the transportation and construction costs in terms of labour and machinery required.

Author Keywords. Fibre reinforced concrete, High Performance Concrete, High Speed Railway bridges, Precast concrete, Prestressed concrete, Railway bridge, Structural design.

ID: 159

The roll of physics-motivated analytical models in the development of new monitoring strategies for floating wind turbines

Francisco Pimenta[1]

[1]CONSTRUCT, Faculty of Engineering of the University of Porto

Abstract

Wind energy has experienced significant growth over the last years that is expected to continue, in particular with the emergence of floating solutions that allow exploring deeper water depths. However, and if the very ambitious goals defined by Europe, in general, and Portugal, in particular, are to be met, the currently available technological solutions need to be further developed and made more efficient. This is only possible by improving not only numerical modelling skills, but also the current understanding of the complex physical and dynamical processes that govern their behaviour.

For these very particular structures, fatigue scenarios, most often than not, play a decisive role in their design, that are naturally evaluated based on design scenarios and complex numerical models. In order to validate and improve these models, it is of vital importance to estimate the internal forces actually registered during the structure lifetime. Additionally, and since the environmental conditions experienced under operation are clearly distinct from those assumed for design purposes, these estimates can also be used as a live tracking tool of the consumed and remaining fatigue damage. This is particularly relevant as a decision aid tool for the wind farm operator to make the exploration as efficient as possible since these structures incorporate different active control algorithms that aim at properly balancing the captured wind power and the induced structural loads.

If the most obvious way to monitor the stresses time history on a given cross section is by installing strain gauges there, it is not possible, or desirable, to instrument all the critical sections of all wind turbines in a given wind farm, making predictive models based on operational conditions an important tool. In this field, and with the significant increase of available computational power over last years, machine learning approaches based on very large training data sets have become more and more feasible and have already been shown to deliver robust predictions for most practical purposes. However, they often lack the capability of providing significant physical insight into the dynamics of the structure, which makes extrapolations away from the training conditions (for instance, periods where different control algorithms have been used) harder and less robust.

In this work, we discuss the advantages of developing these predictive models within a robust theoretical framework laid on strong physics grounds and present different methodologies to estimate the internal forces on a wind turbine tower for onshore and offshore applications. Following the discussion above, these methodologies have been developed from a purely analytical and physics informed point of view, validated with time domain aeroelastic simulations and are now being tested in different experimental campaigns of full scale operating wind turbines, where they are expected to be a very relevant tool in making these systems more and more efficient.

Author Keywords. floating wind turbines, analytical mechanics, structural health monitoring

ID: 163

Evaluation of Train-Structure Interaction Using a Railway Bridge Dynamic Model

Marco Antonio Peixer[1], Pedro Montenegro[2], Rui Calçada[3]

[1]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (peixer@fe.up.pt) ORCID 0000-0003-2554-0700

[2]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (paires@fe.up.pt) ORCID 0000-0001-5699-4428

[3]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (ruiabc@fe.up.pt) ORCID 0000-0002-2375-7685

Abstract

The High-Speed Railways (HSR) is a sophisticated system encompassing various technical aspects, such as operations, infrastructure, and rolling stock. Bridges are among the most essential infrastructures, enabling seamless connections between regions. Despite the reduced travel time and costs associated with HSR's enhanced speed, safety and comfort must remain a top priority. The dynamic interaction between trains, tracks, and bridges can cause significant vibrations in substructures and impact train performance, necessitating a deeper understanding of the train-track-bridge system. This research is fundamental to ensure the continuous development of HSR while preserving the bridge's structural integrity and operational safety. However, current models available in literature lack the ability to introduce multiple interfaces of the train-bridge system simultaneously, such as wheel-rail interaction, track-bridge interaction, and soil-structure interaction. Therefore, this study aims to bridge this gap by developing a robust, versatile, and fully 3D train-bridge-soil interaction methodology that will allow the assessment of the dynamic behavior of the train-bridge system and its interaction with the surrounding soil in portal frame type bridges. The model was developed through the interaction between the MATLAB® and ANSYS® FEM platforms, allowing for a more comprehensive analysis of the bridge-soil-vehicle system. The ANSYS AAS MATLAB toolbox played a crucial role in this process, allowing the execution of multiple instances of ANSYS® via MATLAB® as well as their interaction. The wheel-rail interaction element was created to simulate wheel-rail contact, which can assess structure behavior at any level of complexity, including nonlinear systems. This was achieved by utilizing ANSYS® Mechanical APDL User Programmable Features (UPFs), which allows the creation of a new element in the ANSYS® software with the desired properties. This new modeling technique enable new methods of analyzing scenarios with varying degrees of complexity, such as structures with important interactions with the surrounding soil, scenarios that present important nonlinearities, and situations where the train is exposed to lateral loads. The outcomes of this study will help to develop improved recommendations for bridge design, resulting in more reliable and cost-effective railway infrastructure.

Author Keywords. Train-bridge interaction, high-speed Railways, dynamic analysis, train running safety.

ID: 164

Development of a Digital Twin model for fatigue assessment of railway steel bridges

Idilson Nhamage[1], Rui Calçada[2], José Matos[3]

[1]CONSTRUCT-LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202011161@edu.fe.up.pt) ORCID 0000-0001-9854-7677

[2]CONSTRUCT-LESE, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruiabc@fe.up.pt) ORCID 0000-0002-2375-7685

[3]ISISE, Department of Civil Engineering, University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal (jmatos@civil.uminho.pt) ORCID 0000-0002-1536-2149

Abstract

This study proposes a Digital Twin (DT) model that combines a Fatigue Analysis System (FAS) and BIM modelling, with the goal of improving fatigue assessment efficiency in the operational processes of railway steel bridges. The FAS is based on a finite element numerical model (implemented in ANSYS® software) to obtain part of input for computing fatigue damage in accordance with the principles outlined in the Eurocodes and it is implemented in MATLAB® software. The Várzea bridge, in Portugal, was chosen as a pilot project for model implementation. With the implemented methodology, it is possible not only to obtain numerical values of fatigue state results in a given bridge connection detail, but also to automatically represent this information in the 3D BIM model using a colour-scale based visualisation process. Furthermore, a simulation and continuous updating of the model is implemented for permanent re-evaluation of the damage state or whenever necessary, with the main input variables being the traffic and geometric conditions of the bridge. The current stage of model development shows promise for achieving the desired goals.

Author Keywords. Digital Twin, fatigue damage, Fatigue Analysis System, BIM, railway steel bridge

ID: 165

Bidirectional seismic fragility functions for RC structures. State-of-the-art: a closeness to reality

Gabriel Hojda[1], Ruben Munteanu[2], Humberto Varum[3]

[1]Technical University of Civil Engineering Bucharest, Bucharest, Romania, (gabrielhojda@phd.utcb.ro) ORCID 0000-0003-4423-4047

[2]University Politehnica of Bucharest, Bucharest, Romania, Romania, (ruben.munteanu@upb.ro)

[3]University of Porto, Porto, Portugal, (hvarum@fe.up.pt)

Abstract

Seismic performance is described by designating the maximum allowable damage state for an identified earthquake ground motion. A comprehensive methodology for assessing the seismic performance is required which can be attained by developing seismic fragility function of the structures. To estimate the seismic fragility functions of the structures, a set of nonlinear time history analysis, on models subjected to unidirectional ground motions, for both directions, is carried out. The existing practice does not consider the fact that the seismic ground motions act bidirectionally, which leads to underestimating of the damage state a building may be in the event of an earthquake. In this regard, the main objective of this paper is to synthesize the little information found in the literature, to propose a new approach regarding the development of fragility curves from bidirectional seismic ground motions, as well as to compare the fragility curves for a 3D RC building subjected to unidirectional and bidirectional seismic ground motions. The whole process, from the running of the nonlinear time history analysis to the determination of the seismic fragility curves, which will be used for comparison, will be carried out using a commercial software called MATLAB.

Author Keywords. fragility assessment, bidirectional ground motions, Force Analogy Method, damage index.

ID: 169

Drought monitoring and assessment using the standardized precipitation index in four different sites in Timor-Leste

Justino da C. Soares[1], Paulo J. R. Santos[1,2], Tiago J. F. Ferradosa[1,2], Mahdi Alemi[2], Ana Margarida Bento[2]

[1]Hydraulics, Water Resources, and Environmental Division, Department of Civil Engineering, Faculty of Engineering of the University of Porto, 4200-465 Porto, Portugal

[2]Interdisciplinary Centre of Marine and Environmental Research of the University of Porto (CIIMAR), 4450-208 Matosinhos, Portugal

Abstract

Drought is an important hazard in water resources management in Timor Leste, where the water resources information and analysis is often scarce. Therefore, drought monitoring and assessment using the Standardized Precipitation Index (SPI) is an important indicator of water availability. Temperature is also an important hazard that can affect water availability, as it controls evapotranspiration rates. The study presented in this paper examined droughts in four sites of Timor Leste using the Standardized Precipitation Index (SPI), which is useful for proper management of water resources to cope with water scarcity in the future. The reasons for the significant differences in the frequency of occurrence of dry months are provided. The indices are evaluated in terms of their applicability for drought monitoring. This study can be an essential step in addressing the vulnerability to drought hazards in Timor Leste and developing a drought mitigation strategy. This paper using 30 years precipitation data of four station of the period 1992 – 2021 (EDTL-Dili, Maubara, Letefoho and Laclubar). Where the calculation of the SPI, which requires a series of data with at least thirty years and ends from the probability density functions that describe the historical series of precipitation in the different scales of time. Finally, adjust the normal and gamma distributions. Two site station are in flat area (Dili and Maubara) and others two site station in mountains area (Letefoho and Laclubar). The reason to compare the result of SPI on the flat area and mountains area. And the SPI indices to define, initially and adjusting the series of precipitation values, respectively, to a gamma distribution and later to a normal distribution. The results of this study show that in all four locations where the indices of category near normal are higher, there is a possibility that the category is dry, which will increase the risk to the land and water. Thus, this research can serve local communities and the government of Timor Leste in adjusting their strategies to cope with the expected future droughts in the country.

Author Keywords. Drought; Climate change; Water scarcity; Early warning system; Adaptive management; Standardized Precipitation Index (SPI)

ID: 192

Enhancing Railway Bridge Inspection with Computer Vision and Deep Learning

Rafael Cabral[1], Diogo Ribeiro[2], José Correia[3]

[1]CONSTRUCT - LESE, Faculty of Engineering, University of Porto, Porto, Portugal
up201609762@edu.fe.up.pt 0000-0002-9214-4823

[2]CONSTRUCT - LESE, School of Engineering, Polytechnic of Porto, Porto, Portugal 0000-0001-8624-9904

[3]CONSTRUCT - LESE, Faculty of Engineering, University of Porto, Porto, Portugal 0000-0002-4148-9426

Abstract

Railway bridges are a vital component of infrastructure, but they are vulnerable to material and structural degradation, exposure to environmental conditions, and heavy loads. Regular inspection and monitoring can provide valuable information for maintenance, repair, and reinforcement operations. However, traditional inspection methods can be time-consuming, costly, and pose risks to human health.

Fortunately, computer vision technology provides a promising solution for contactless inspection and monitoring of railway bridges, enhancing process efficiency, lowering costs, and improving safety. This article focuses on the latest computer vision methodologies for railway bridge inspection and monitoring, including procedures for integrating valuable data into decision-making systems.

Using computer vision techniques, particularly those based on deep learning, can help identify local damages and anomalies in railway bridges. Computer vision can also enable the measurement of strains, displacements, and accelerations under heavy traffic loads, including the management of large volumes of data for structural health monitoring.

In conclusion, computer vision technology provides a promising solution for the contactless inspection and monitoring of railway bridges. By using computer vision and deep learning techniques, railway bridge inspection and monitoring can be performed more efficiently, accurately, and safely. With the ability to detect damage and anomalies quickly and accurately, maintenance crews can act swiftly and prevent further damage, ensuring the safety and longevity of railway bridges.

Author Keywords. Computer vision, railway bridge, inspection, deep learning.

Strengthening Ancient Metallic Bridges: theoretical overview of Retrofitting Techniques based on Fatigue and Fracture Mechanics approaches

João Arrojado[1], José A. F. O. Correia[2], Diogo Ribeiro[3], Anna Rakoczy[4]

[1]CONSTRUCT, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201606508@fe.up.pt) ORCID 0000-0001-7424-4671

[2]CONSTRUCT, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (jacorreia@fe.up.pt) ORCID 0000-0002-4148-9426

[3]CONSTRUCT, Instituto Superior de Engenharia do Porto, Rua Dr. Bernardino de Almeida 431, 4249-015 Porto, Portugal (drr@isep.ipp.pt) ORCID 0000-0001-8624-9904

[4]Institute of Roads and Bridges, Department of Civil Engineering, Warsaw University of Technology, Poland (anna.rakoczy@pw.edu.pl) ORCID 0000-0003-1208-5729

Abstract

European Union outlined safety, efficiency, environmental friendliness of freight transport and people's mobility as a top priority for the next few years. During the 20th century, the construction of metallic railway bridges underwent a strong development, meaning that governmental and institutional entities have the necessity to find reasonable solutions to extend the operational lifetime of these structures based on cost-benefit analysis, promoting the circular economy of metals. The fatigue phenomenon is widely known as the main cause of damage in bridges. Recently, CFRP has emerged as a potential repairing solution and suits very well because of his high strength-to-weight ratio and increases static and fatigue resistance. Goals were set for Europe to be climate neutral by 2050, which means an economy with net zero greenhouse gas emissions. New solutions for these infrastructures must be investigated, using recycled and eco-friendly CFRP materials and additive manufacturing technologies. Although fatigue in metals has been studied over 160 years, many problems remain unsolved. This paper presents a theoretical overview on the fatigue and fracture mechanics approaches to assess the performance of these new techniques to extend the operational lifetime of old metallic bridges.

Author Keywords. Metallic Bridges, Retrofitting, CFRP, Additive Manufacturing.

ID: 220

Smart Road Markings: Anti-Aging, Photoluminescence, Self-Cleaning, and Thermochromism

Orlando Lima Jr.[1, 2], Iran Rocha Segundo[1, 2], Laura Nascimento Mazzoni[3], Elisabete Freitas[1], Joaquim Carneiro[2]

[1]Department of Civil Engineering, ISISE, ARISE, University of Minho, 4800-058 Guimarães, Portugal (efreitas@civil.uminho.pt)

[2]Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, 4800-058 Guimarães, Portugal

[3]Department of Transportation Engineering, University of São Paulo, 13566-590 São Paulo, Brazil (laura.mazzoni@usp.br)

Correspondence: orlandojunior.jr@hotmail.com; iran@fisica.uminho.pt; carneiro@fisica.uminho.pt

Abstract

Road markings (RM) consist of two distinct layers: the paint layer and the retroreflective layer. Together, they work as a system and serve as a safety feature. Some advances in this topic are related to making this system smart and with new abilities to improve their durability and road safety. These capabilities include anti-aging, photoluminescence, self-cleaning, and thermochromism. Thus, the objective of this research is to review the state-of-the-art and identify potential topics for smart RM, materials used, functionalization techniques, and the main results.

Author Keywords. transport infrastructures, pavement markings, smart materials, smart paints, road safety

ID: 225

Seismic risk assessment for the residential building stock of Bucharest with application to the insurance system

Bogdan Gheorghe[1], Radu Văcăreanu[2], Humberto Varum[3]

[1]Technical University of Civil Engineering Bucharest, Bucharest, Romania,

(ionut-bogdan.gheorghe@phd.utcb.ro)

[2]Technical University of Civil Engineering Bucharest, Bucharest, Romania,

(radu.vacareanu@utcb.ro)

[3]University of Porto, Porto, Portugal, (hvarum@fe.up.pt)

Abstract

Seismic insurance models contribute significantly to increasing resilience for existing structures in seismic risk prone areas. The present study aims to calculate the expected insurance premium for the residential building stock of Bucharest, Romania, subjected to seismic action in its service lifetime based on probabilistic seismic loss assessment. The methodology used involves the probabilistic assessment of the seismic risk, in the sense of quantifying the expected seismic losses for a set of damage limit states taking into account the seismic hazard and the seismic vulnerability of the existing residential building stock. The loss estimation is compared and calibrated with the data from the Vrancea earthquake of March 4, 1977. The expected insurance premium is then evaluated based on the probabilities that the structure exceeds a set of discrete limit state thresholds and the average costs associated to them. The study is presented through a numerical example that uses data from the most recent census performed in 2011, from that the residential building stock is discretized in seven main typologies and dived in other categories as function of the level of seismic design code and the height regime. Hence, the expected insurance premium is calculated for each structural typology, taking into consideration a monopoly market-based insurance model and risk neutrality of the insurance companies.

Author Keywords. seismic risk, loss assessment, and seismic insurance.

ID: 231

Investigation on wave attenuation in offshore aquaculture systems

Filipe Miranda[1], Alexandre Carvalho[2], Ana Margarida Bento[3], Paulo Rosa-Santos[4], Francisco Taveira-Pinto[5] Tiago Fazeres-Ferradosa[6]

[1]IHRH - Instituto de Hidráulica e Recursos Hídricos, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (filipemiranda@fe.up.pt) ORCID 0000-0002-3948-2989

[2]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202004933@edu.fe.up.pt)

[3]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (anabento@fe.up.pt) ORCID 0000-0002-8386-807X

[4]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (pjrsantos@fe.up.pt) ORCID 0000-0002-3768-3314

[5]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (fpinto@fe.up.pt) ORCID 0000-0003-4337-8428

[6]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (tferradosa@fe.up.pt) ORCID 0000-0002-8549-3320

Abstract

With the goal of a sustainable future, the member stated of the United Nations (UN) have adopted the 2030 Agenda for Sustainable Development, which includes urgent goals for various areas of global development, such as water management, food resources, climate change, among others. Furthermore, the European Union (EU) has launched the Blue Growth Strategy for a sustainable development of the European marine economy in areas such as blue energy, aquaculture, maritime tourism, and marine mineral resources. Despite these actions, the impacts of climate change continue to increase worldwide. Moreover, continued population growth will increase pressure on increasingly densely populated coastal areas and United Nations Food and Agriculture Organization (FAO) reports that the world would need to increase its food production by 60% by 2050 to meet global food demand.

To optimize their operational and capital expenditures, several offshore sectors, including wind energy and wave energy, are combining their technological resources. Despite this, the use of aquaculture systems for wave attenuation has received little attention. The AquaBreak project aims to develop a sustainable and cost-effective aquaculture system that combines aquaculture activities with coastal protection and decarbonization. The current study is investigating the wave energy attenuation of a floating offshore seaweed longline aquaculture system. Physical modelling testing was conducted at the wave-current flume of the Hydraulics Laboratory of the Faculty of Engineering of the University of Porto (FEUP) to a scale of 1:50, and environmental conditions representative of the North Sea. Two resistive free water surface wave probes were used to measure wave height and wave period upstream and downstream of the aquaculture system model, while the depth average current velocity was measured by a Nortek vectrino device. The seaweed growth in this offshore aquaculture system occurs perpendicular to the main direction of wave propagation, which contributes to its wave attenuation potential. The results of the current study exhibited a wave attenuation of 12%, with a positive correlation between wave attenuation and decreasing wavelength. These results suggest that multi-purpose nature-based solutions using offshore aquaculture systems can be achieved both for food production and coastal protection.

Author Keywords. Blue economy, Physical modelling, Offshore aquaculture, Coastal protection.

ID: 233

Experimental study on scour around underwater pipelines

Tiago Fazeres-Ferradosa[1], Lino Monteiro[2], Filipe Miranda[3], Cristiana Ferreira[4], Francisco Taveira-Pinto[5]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (tferradosa@fe.up.pt) ORCID 0000-0002-8549-3320

[2]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202006284@edu.fe.up.pt)

[3]IHRH - Instituto de Hidráulica e Recursos Hídricos, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (filipemiranda@fe.up.pt) ORCID 0000-0002-3948-2989

[4]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cristiana@fe.up.pt) ORCID 0000-0001-5998-6220

[5]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (fpinto@fe.up.pt) ORCID 0000-0003-4337-8428

Abstract

Underwater pipelines are a critical infrastructure for transporting a range of important resources, including natural gas, oil, petroleum products, and electricity cables. Pipeline design must consider the development of scour. The presence of the pipeline alters the flow patterns near the structure which leads to the amplification of the bed shear stress around the pipeline. This interaction of the soil, fluid and structure can result in increased sediment transport and the development of scour holes. Scour is a major cause of failure in underwater pipelines. Scouring has the potential to reduce the soil´s bearing capacity and ultimately lead to the instability and collapse of the pipeline.

The aim of this study is to characterize and investigate the scour patterns and scour depth near underwater pipelines. Physical modelling tests were performed for a 0.6 m diameter pipeline near a 15.7 m for 8 m platform. The experimental tests were conducted in the wave-current flume of the Hydraulics Laboratory of the Faculty of Engineering of the University of Porto (FEUP). These tests included two physical models, which were built for a 1:50, and 1:30 model scales of the North Sea. The wave height and wave period were measured using resistive free water surface wave probes, and the depth average current velocity was measured with a Nortek vectrino device. The scour holes and deposition zones were characterized using an advanced image-based approach, the close-range photogrammetric technique. The results of this study lay the foundation for further extensive experimental campaigns with the aim of improving the existing scour prediction methods. Accurately predicting the scour development and patterns can directly contribute to the reduction of design uncertainty.

Author Keywords. Pipeline, Physical modelling, Scour, Sediment transport.

ID: 234

A critical review of energy retrofitting trends in residential buildings with a particular focus on Jordan

Ahmad Almomani[1], Eva Barreira[2], Ricardo Almeida[3]

[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202103251@edu.fe.up.pt) ORCID 0000-0003-2086-7261

[2]CONSTRUCT-LFC, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (barreira@fe.up.pt) ORCID 0000-0002-1343-5578

[3]Departamento de Engenharia Civil, Instituto Politécnico de Viseu, Campus Politécnico de Repeses, 3504-510 Viseu, Portugal, (ralmeida@estv.ipv.pt) ORCID 0000-0002-9846-6081

Abstract

Energy sustainability is a primary concern of the 21st century, as greenhouse gas emissions from traditional energy sources cause harmful effects on the global climate and threaten human well-being. Also, traditional energy resources, such as fossil fuel, are draining over time, pushing for the discovery of alternative energy resources, i.e., renewable energy. In Jordan, the rapid population growth due to the instability of the surrounding countries and the increased immigration to Jordan throughout the past decades, the high energy imports due to the lack of natural energy resources, and urbanization exacerbate the energy security issues. Thus, optimizing energy consumption and seeking alternative energy resources is necessary to overcome the abovementioned challenges. Buildings consume more than 40% of the total energy consumption worldwide, primarily for heating and cooling, producing up to one-third of total GHG emissions. In Jordan, residential buildings represent 86% of the entire existing building stock, accounting for 44% of energy consumption, primarily for cooling and heating. Therefore, optimizing the energy performance of existing residential buildings through green retrofitting can have a higher impact on energy sustainability. This study aims to comprehensively review the current trends in energy retrofitting of residential buildings with a particular focus on Jordan. Researching such a topic on a country level is one of the future research agendas of global review studies. For this review, an extensive keyword search was carried out throughout the SCOPUS and Web of Science databases. Inclusion and exclusion criteria were set, and a total of 17 relevant studies were accumulated, which were then critically analyzed and benchmarked against global retrofit review studies' trends to identify gaps in the literature. The selected documents were analyzed based on four main parameters: sustainable retrofitting assessment, pre- and post-retrofit measurement and verification, type and number of energy efficiency measures, and the software utilized for simulation and optimization. The findings indicate a lack of research covering the three sustainability dimensions, with few studies performing the pre-retrofitting measurement and verification procedure for validating and calibrating the energy models. Also, none of the studies investigated the post-retrofitting measurement and verification of retrofitted buildings. Additionally, there is a lack of research on using Building Information Modelling (BIM) for energy retrofitting in Jordan, an important emerging area that requires further investigation. To sum up, this study identifies gaps in the literature. It provides recommendations for future research in energy retrofitting of residential buildings in Jordan, aiming to optimize energy consumption and promote energy sustainability. The results of this study contribute to the knowledge of energy retrofitting in the context of Jordan and provide insights for similar research on a country level.

Author Keywords. Energy retrofitting, Energy efficiency, Residential buildings, Review, Jordan

ID: 263

Bills of Data - Conceptualizing the sustainable construction version of Bills of Quantities

Pedro Mêda[1], Hipólito Sousa[2]

[1]IC - Instituto da Construção, CONSTRUCT/GEQUALTEC - Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (pmeda@fe.up.pt) ORCID 0000-0003-4380-5530

[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (hipolito@fe.up.pt) ORCID 0000-0001-8335-0898

Abstract

Since ancient times Bills of Quantities (BoQ) have been the basis for design teams to communicate technical options and works to be made to contractors and for these to obtain payments from the owners. Although the type of contract can influence the detail to which extent the BoQ is set during the design phase, due to other requirements that need to be fulfilled, in the end, an extensive list of works and quantities is needed. In many countries, the regulations set this document as a deliverable at the handover phase. Bill of Quantities organization has been widely discussed in the literature together with its future given the increasing digitalisation adoption. While some authors discuss the end of BoQ with Building Information Modelling (BIM), others advocate the opposite, stating that BoQ will remain and eventually gain more space as the central project deliverable from modern design and construction.

Based on the BoQ literature review and grey literature on construction trends, namely twin transition-associated requirements, and a focus group discussing findings, the present research aligns with the vision that BoQ will strengthen its space as a key project deliverable.

To support this vision the research develops a framework evidencing how Bill of Quantities as we know has unique capacities to support several requirements and achievements that are expected to be accomplished as part of a construction 4.0 vision. In this respect, the trends on Digital Product Passports (DPP), the implementation of Digital Building Logbooks, the data needs supporting Level(s), warranties management, and waste audits, constitute some of the examples to be explored. Given their transversal role and relevance, BoQ is common a element to all construction process stakeholders, from owners to facility managers, including design teams, contractors, and supervisors.

Finally, as part of the novelty and contributions to the body of knowledge, the concept of “Bills of Data” is introduced and detailed providing a clear picture of the reasons for the statement on BoQ key role.

Author Keywords. Bill of Quantities, Data, Management, Digitalization, Sustainability

ID: 272

Damage detection of reinforced concrete structures based on period elongation

Reihane Shafie Panah[1], Jose Melo[2], Humberto Varum[3]

[1]Departmento de Engenharia Mecânica, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up202111328@fe.up.pt)

[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (Josemelo@fe.up.pt)

[3]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (hvarum@up.pt)

Abstract

Damage detection of structures is a crucial issue of structural health monitoring since it affects structural performance and cause human or economic losses. The feasibility and the cost optimization are the most important goals for the simplified monitoring system to favor a widespread use of such systems. During the past two decades, a significant number of studies have been carried out in the field of Non-destructive Damage Evaluation (NDE) methods using the changes in the dynamic response of a structure. The NDE methods can be classified into four levels, according to the specificity of the information provided by a given approach: (I) Level I methods, that only identify if damage has occurred; (ii) Level II methods, that identify if damage has occurred and simultaneously determine the location of damage; (iii) Level III methods, that identify if damage has occurred, determine the location of damage as well as estimate the severity of damage; (iv) Level IV methods, that identify if damage has occurred, determine the location of damage, estimate the severity of damage and evaluate the impact of damage on the structure. Each level of damage identification described above requires a gradual increasing amount of data and more complex algorithms. Consequently, their set-up and effectiveness often require increasing costs, with higher error probability.

There are many methods available for damage identification such as those based on natural frequency changes, mode shape changes, mode shape curvature changes, dynamically measured flexibility, modal strain energy, artificial neural networks (ANNs) and frequency response functions (FRFs), most of them have their own positive and negative attributes. All the different damage identification methods are based on the detection of changes in the dynamic properties of structures because they can provide rapid and relatively cost-effective evaluation of large structures. The final purpose of this review is to investigate the elongation of the fundamental period of buildings (especially reinforced concrete buildings) as a typical indicator of structural inelasticity during seismic events and consequent damage accumulation and its correlation with engineering demand parameters. Furthermore, it investigates the benefits of using sensor data from ambient vibrations and strong ground motion.

Author Keywords. structural monitoring; ambient vibration; period elongation; vulnerability modelling; seismic risk.

ID: 275

Hybrid alkaline cements: a feasible alternative to Portland cement

Filipe Almeida[1], Castorina S. Vieira[2], Nuno Cristelo[3], Ana Fernández-Jiménez[4], Maria de Lurdes Lopes[5]

[1]CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (filipe.almeida@fe.up.pt) ORCID 0000-0002-0437-1314

[2]CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cvieira@fe.up.pt) ORCID 0000-0001-6328-4504

[3]CQ-VR, University of Trás-os-Montes e Alto Douro, 5000-801 Vila Real, Portugal (ncristel@utad.pt) ORCID 0000-0002-3600-1094

[4]Instituto de Ciencias de la Construcción Eduardo Torroja (IETcc-CSIC), C/. Serrano Galvache, 4, 28033 Madrid, Spain (anafj@ietcc.csic.es) ORCID 0000-0002-5721-2923

[5]CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (lcosta@fe.up.pt) ORCID 0000-0002-2390-4825

Abstract

Science is being called to aid society developing solutions towards a more promising world within the framework of United Nations 2030 Agenda for Sustainable Development. The different industrial sectors are showing to be committed with the need of implementing procedures leading to the reduction of the carbon footprint. This work involves lowering the use of raw materials from natural sources and the optimization of the consumption of energy during the operating activities.

Cement industry still remains as one of the main responsible industrial activities for greenhouse gas emissions. It is known that concrete is the second most-consumed material (Gagg 2014; Palomo et al. 2021), just after water, and that its use is essential to build the infrastructures allowing a proper quality-of-life of society. As the key constituent of concrete, Portland cement is commonly used in considerable dosages, which suggests being important to find more sustainable alternatives to this important building material. Hybrid alkaline cements might be considered a possible solution within this context.

Hybrid alkaline cements are obtained through the chemical activation (alkaline activation (Palomo et al. 2014)) of blended cements (Lothenbach, Scrivener, and Hooton 2011; Schöler et al. 2015) consisting of reduced content of Portland clinker and supplementary cementitious materials, such as natural pozolans (e.g., volcanic ash), artificial pozolans (e.g., metakaolin) or industrial by-products (e.g., blast furnace slag, low-Ca metallurgical slags or fly ash) that act as precursors. In addition, an alkaline additive is required. The combination of those materials usually leads to the formation of two types of gels: C-(A)-S-H gel (C-S-H gel associated with the clinker reaction and Al from the precursors); and (N,C)-A-S-H gel or C-A-S-H-like gel (depending on the chemical composition of the precursors) (García-Lodeiro, Fernández-Jiménez, and Palomo 2015; García-Lodeiro et al. 2017). The presence of the alkaline additive is a contribution to reduce the setting times and to improve the early-age mechanical strengths. An important feature of this type of cements is that, contrary to thermal curing commonly used in alkali-activated materials, curing can be carried out at ambient temperature. In addition, it is worth mentioning that hybrid cements can achieve identical mechanical strengths to Portland cement for late-age curing times.

This work is intended to provide insights into hybrid cements. A literature review was carried out in order to collect information on mix designs, reaction kinetics, mechanical behaviour and reaction products of this type of cements. The outcomes of previous studies show that hybrid cements have potential to be considered as a feasible alternative to Portland cement. Considering this circumstance, it seems to be reasonable that efforts should be undertaken to boost the use of hybrid cements in the building and construction sector. Naturally, legislation and standards should be updated in order to allow using these cements. In addition, research work on this topic will be

essential to conquer the confidence of key construction professionals such as designers and contractors. It is expected that the time frame to accomplish this goal could be reduced in the case of having the cement industry directly involved in the process, i.e., in the management and preparation of raw materials, manufacturing and distribution of hybrid cements.

Author Keywords. Hybrid alkaline cements, sustainable building materials, waste valorisation.

ID: 289

Masonry partition walls affected by de vertical deflection of structural elements – A Review

Rui Sousa[1], Hipólito Sousa[2], Humberto Varum[3]

[1]CONSTRUCT - Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruysousa@fe.up.pt) ORCID 0000-0003-3855-3252

[2]CONSTRUCT - Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (hipolito@fe.up.pt) ORCID 0000-0001-8335-0898

[3]CONSTRUCT - Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (hvarum@fe.up.pt) ORCID 0000-0003-0215-8701

Abstract

Damage in non-structural partition walls caused by the vertical deflections of adjacent structural slabs has been reported in existing buildings during the last decades in Portugal. This anomaly and its repairing can impair the performance, economic and environmental sustainability of the building's life cycle. On the other hand, there is an absence of more detailed design and construction specifications in European standards to prevent this type of damage in partition walls. Moreover, there is no recent and sufficient scientific research, supported by laboratory experimentation and numerical simulation, about the behavior of these non-structural walls in such conditions. The aim of this work is to present a state-of-the-art review and to identify research needs work about this particular subject.

Author Keywords. Building Construction; Structures; Deflections; Partitions; Masonry, Mechanical Performance.

ID: 290

Sustainable Drainage Systems: a solution for rainwater drainage in Luanda, Angola

Cynthia Reyes[1,2], Paulo Rosa Santos[2], Manuel Pacheco Figueiredo[2]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade Agostinho Neto, Rua Rua 21 de Janeiro, Luanda, Angola (up201911747@edu.fe.up.pt

[2]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (pjrsantos@fe.up.pt) ORCID 0000-0002-3768-3314; (mpfiguei@fe.up.pt) ORCID: 0000-0001-8674-0330

Abstract

Over the past 40 years, the stormwater management paradigm has changed. The idea of considering the rainwater as a "waste" that should be transported from one point to another by conventional sewers was modified. Today, the interest of integrating the urban water cycle into the natural cycle of watersheds is evident (Blal Adem Esmail, 2020). The rainwater is now seen as a resource to be reintegrated into nature by means of solutions that promote infiltration, storage and/or reuse (McGrane, 2016). To achieve this objective, several issues related to the hydrology of the site, water quality, complexity and function of the solutions to be implemented, and the socio-economic constraints must be addressed. However, the climatic conditions and their worsening due to climate changes in recent times, should also be considered in the analysis (Latif, 2011). The developing countries face additional challenges.

Luanda, the capital of Angola, has 18 basins that contain the main macro rainwater drainage lines. The few ditches that make up the macro drainage network of the city face problems such as: uncontrolled disposal of garbage, unauthorized occupation of their banks, extreme peak discharges in the rainy season, due to torrential rains, the uncontrolled drainage during those episodes coming from the musseques, which are still lacking basic sanitation networks. Because of this, rivers and water lines in the city overflow, especially in places closer to Bahia, and in the neighborhoods that appear in an uncontrolled way on the banks of the rivers (Development, 2013).

A significant part of the city of Luanda is occupied by musseques, which are mostly served by unpaved roads and do not have a formal drainage system. In addition, the existing stormwater networks, mainly composed of ditches and natural water lines, do not have regular rehabilitation, maintenance or modernization operations. Thus, the implementation of sustainable solutions, supporting the existing conventional network and combined with a maintenance and preventive rehabilitation program, would help reducing extreme runoff volumes and in many cases would avoid floods caused by rainfall events of small magnitude.

The ongoing research intends to propose and develop sustainable solutions to be implemented in Luanda to reduce drainage problems. Hence, with the aid of SWMM software, and by simulating the behavior of a case study network, considering also the possible implementation of sustainable solutions to support it, and for different rainfall events linked to selected return periods, the effectiveness of those solutions on the drainage system will be evaluated.

Author Keywords. Low impact development; Urban floods; Drainage systems.

ID: 291

Identifying the moisture content in building materials using machine learning models

Leticia C. M. Dafico[1], Eva Barreira[2], Ricardo M. S. F. Almeida[3], Romeu S. Vicente[4]

[1]Construct-LFC, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201911110@up.pt) ORCID 0000-0003-3650-7818

[2]Construct-LFC, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (barreira@fe.up.pt) ORCID 0000-0002-1343-5578

[3]Departamento de Engenharia Civil, Instituto Politécnico de Viseu, Campus Politécnico de Repeses 3504-510 Viseu, Portugal (ralmeida@estv.ipv.pt) ORCID 0000-0002-9846-6081

[4]RISCO, Departamento de Engenharia Civil, Universidade de Aveiro, Campus Universitário de Santiago 3810-193 Aveiro, Portugal (romvic@ua.pt) ORCID 0000-0002-5456-1642

Abstract

Moisture is one of the main causes of defects in the external and internal building fabric, frequently leading to degradation and decay. The complexity of moisture phenomena makes it more challenging to interpret the results during building inspections. However, proper diagnosis and prevention of moisture damage are of paramount importance to guarantee the durability of the building and its components, the comfort of the users, and the quality of the indoor environment since high levels of moisture can lead to mold growth, surface condensation, salt crystallization, and even reduced structural strength.

Infrared Thermography (IRT) is a non-destructive technique (NDT) that can be used to map the moisture distribution in building materials and identify areas with atypical moisture content since there are physical phenomena that lead to changes in the surface temperature in moist areas [(Barreira & Almeida, 2019; Garrido et al., 2019; Grinzato et al., 2011)]. Despite its potential to detect moisture, there is a gap in the literature regarding the identification of quantitative criteria for the interpretation of results due to the variability of the phenomena involved in the humidification and drying of materials. Therefore, obtaining surface temperature criteria indicative of moisture is an important issue that must be addressed.

In recent years, the construction industry is experiencing a technological revolution driven by digitalization and automation. Several studies have been conducted to integrate the results of building inspection technologies with machine learning techniques by developing algorithms that make it possible to identify and automate the identification of defects in buildings, reducing the subjectivity in the analysis of inspection results.

Although the recent advances in image-based techniques and computational methods for building diagnosis, their use for moisture assessment still needs to be fully exploited. Thus, this work developed models using artificial neural networks (ANN) to predict the moisture content of building materials based on the thermal gradient between moist and dry areas. One ANN model was also developed to predict the maximum thermal gradient of saturated materials in different environmental conditions.

The training and testing datasets were obtained with the WUFI software, which simulates the coupled heat and mass transfer in building materials. Four building materials were selected for the analysis: brick, concrete, granite, and limestone. The temperature and relative humidity of the air chosen for the simulation ranged from 5 to 25°C and from 50 to 90%, respectively, in 30 combinations of environmental conditions. The drying process of these four materials was simulated in each of the 30 scenarios for 65000 hours.

The hygrothermal simulation software tools combined with machine learning techniques enabled the creation of models with high coefficient of determination (R2) values. These models can be used in construction practice to assess the moisture content of moist building materials based on the thermal gradient between areas with and without moisture.

The machine learning algorithms developed can reduce the subjectivity and the dependence on operator experience inherent to inspections with IRT for moisture assessment. In addition, the algorithms represent one step further in quantitative analysis with IRT, contributing to the development of future tools that automatically predict and alert when favorable conditions for moisture-induced damage can occur in buildings.

Author Keywords. Building Construction, Moisture, Machine learning models, Building diagnosis, Hygrothermal behavior

ID: 298

Evaluating the Influence of Manufacturing Tolerances on the Cyclic Behavior of Steel Members

Cyrus Eshaghi[1], Anis Mohabeddine[2], Rui Carneiro de Barros[1], Xavier Romão[1], José Miguel Castro[1]

[1]Construct, Faculty of Engineering University of Porto, 4200-465 Porto, Portugal (cyruses@fe.up.pt)

[2]Faculty of Civil Engineering and Geosciences, Delft University of Technology, Netherlands

Abstract

The main subject of this paper is the impact that manufacturing tolerances have on the cyclic performance of steel members constructed with European I and H-shaped profiles, particularly in moment-resisting frames (MRF). The paper also examines the effectiveness of AI models in anticipating this behavior. Past research has shown that the behaviour of a structural steel member in bending is greatly affected by the variability of geometrical and material parameters. Most previous research that focused on the cyclic behaviour of MFR members used the nominal sections in their research, however regarding the geometry, in Europe, hot-rolled profiles, are produced with dimension tolerances that are specified and limited in the European standard EN 10034. In this research, a numerical study was performed to evaluate the influence of geometrical variability on the behaviour of steel members subjected to cyclic flexural loading conditions. For this purpose, an advanced finite element model was developed in Abaqus and validated against experimental test data. A parametric study was conducted in which the geometrical dimensions of the member were considered as random input. Probabilistic distributions derived from experimental data were defined for each of the 6 random input variables associated with the cross-section dimensions. Then a total set of 2300 samples were generated using Latin Hypercube sampling for a range of profiles (IPE300 to IPE600) and (HEB300 to HEB550) with different lengths to evaluate the effect of dimension tolerances on the behaviour of beams and columns. The results showed that the variability in members behaviour is significant and can cause variation in over strength ratio, energy dissipation, axial shortening, and rotation capacity of the members. Then using machine learning techniques, some models developed to predict rotation and moment at key points of backbone curves. To this aim, various models were evaluated, including nonlinear and linear regression analysis, neural network, decision tree, and random forest.

Author Keywords. Structures, Manufacturing Tolerance, Cyclic Loading, Rotation Capacity, Moment Resisting Frames, Machine learning.

ID: 299

Mitigation of earthquake-induced liquefaction by induced partial saturation in sands

Fausto Molina-Gómez[1], António Viana da Fonseca[2], Cristiana Ferreira[3], Bernardo Caicedo[4]

[1]CONSTRUCT-GEO, Departamento de Engenharia Civil, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (fausto@fe.up.pt) ORCID 0000-0002-8831-0315

[2]CONSTRUCT-GEO, Departamento de Engenharia Civil, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (viana@fe.up.pt) ORCID 0000-0002-9896-1410

[3]CONSTRUCT-GEO, Departamento de Engenharia Civil, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cristiana@fe.up.pt) ORCID 0000-0001-5998-6220

[4]Department of Civil and Environmental Engineering, Universidad de los Andes, Bogotá, Cra. 1 Este #19a-40, Colombia (bcaicedo@uniandes.edu.co) ORCID 0000-0003-4344-09143Ixxxxxxx

Abstract

Soil liquefaction is one of the most complex and instability phenomena characterised by the rapid loss of the strength and stiffness of soil. The instability is caused by the accumulation of pore pressure build-up, which leads to an effective stress equal and high deformations. Typically, the phenomena occur in saturated sandy soils. Hence, induced partial saturation (IPS) techniques have shown promising results for liquefaction mitigation. The IPS allows for mitigating the liquefaction phenomena by increasing the compressibility of the pore fluid, which changes its bulk modulus. Such a process involves the generation of gas in the soil porous. The presence of the gas (e.g. air) creates occluded air bubbles in the pore fluid, reducing the degree of saturation (Sr) and the pore pressure build-up during cyclic loading. This study presents the results of an experimental program aimed at assessing the liquefaction resistance of a Portuguese sand improved by IPS. The tests were carried out for different Sr using a cyclic triaxial apparatus. The results demonstrated that the decrease in Sr improved the cyclic resistance of sandy soils, validating the suitability of IPS to mitigate the earthquake-induced liquefaction effects.

Author Keywords. Liquefaction, induced partial saturation, soil improvement, sands.

ID: 301

Posters displayed in the Symposium

Evaluation of the dynamic behavior of integral railway bridges with soil-structure interaction

David Baldaia[1], Gonçalo Ferreira[2], Marco Antonio[3], Pedro Montenegro[4]

1 Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (up201806077@up.pt) ORCID 0009-0000-3947-1457

[2]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (gcferreira@fe.up.pt) ORCID 0000-0002-9586-3487

[3]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (peixer@fe.up.pt) ORCID 0000-0003-2554-0700

[4]CONSTRUCT - LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal, (paires@fe.up.pt) ORCID 0000-0001-5699-4428

Abstract

This thesis aims to develop skills in the area of experimental and numerical evaluation of the behavior of railway bridges. The work is being developed within the European Project "IN2TRACK3 - Research into optimised and future railway infrastructure", more specifically regarding the evaluation of the dynamic behaviour of portal-frame bridges. Given the interaction between the bridge abutment and the surrounding soil in contact, the behavior of this type of bridges is usually strongly conditioned by the soil.

Therefore, it is intended to develop a study based on an experimental campaign carried out by the railroad research group of FEUP, where the dynamic response of the bridge will be evaluated based on accelerations measured at various locations (walls and top slab). The goal is a finite element numerical model to describe, as accurately as possible, this response. Special attention will be given to how the soil is modeled, as well as its influence on the response of the structure.

Models of the bridge will be developed taking into account the soil interaction, but also without it, in order to more accurately evaluate the influence of this parameter on the response. The work will be developed using the finite element software ANSYS and its own software developed in MATLAB by the FEUP research group.

ID: 10

The Impact of a Dynamic Thermal Insulation System on Indoor Thermal Comfort: Numerical Simulation and Experimental Characterisation

Maria Ribeiro[1], Eva Barreira[2], Ricardo Almeida[3]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[2]CONSTRUCT, Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[3]CONSTRUCT, Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

Abstract

Dynamic thermal insulation systems (DTIS) can adapt to external environment conditions, allowing the reduction of the energy consumption and the increase of occupants' thermal comfort, by controlling heat transfer through the facade.

In this study, the behaviour of a DTIS was assessed through numerical simulation and laboratory tests.

Annual simulations were run in DesignBuilder, to evaluate the behaviour of a low and high mass building located in Porto, when varying the U-value of its walls. The results show that the percentage of time and the severity of discomfort by overheating decreases for higher U-values. They also show that, although thermal mass limits indoor thermal amplitude, the lower thermal mass configuration presented a better performance.

The laboratory tests showed that the prototype of a prefabricated high mass wall with a forced ventilated air gap presented lower thermal resistance than a similar one without ventilation, pointing to its benefits to avoid overheating.

ID: 25

Prediction of rubble-stone masonry walls response under uniaxial compression and shear-compression using 2D particle modelling

Dóris Pereira Delignière[1], Nuno Monteiro Azevedo[2], Ildi Cismasiu[3]

[1]MSc Student, Departamento de Engenharia Civil, Faculdade de Ciências e Tecnologia, Universidade NOVA, Campus de Caparica, Caparica, 2829-516, Portugal (d.deligniere@campus.fct.unl.pt)

[2]Concrete Dams Department, Laboratório Nacional de Engenharia Civil (LNEC), Av. do Brasil 101, 1700-066 Lisboa, Portugal (nazevedo@lnec.pt) ORCID 0000-0001-8838-3760

[3]CERIS and Departamento de Engenharia Civil, Faculdade de Ciências e Tecnologia, Universidade NOVA, Campus de Caparica, Caparica, 2829-516, Portugal (ildi@fct.unl.pt) ORCID 0000-0001-7662-1215

Abstract

The accurate prediction of the structural behaviour of existing ancient stone masonry walls is still a challenging task, both in experimental and numerical modelling, due to their heterogeneity, uncertainty of the material properties and irregularity of stone arrangement.

A 2D particle model (2D-PM), based on the Discrete Element Method is adopted to model uniaxial compression and in-plane shear experimental tests of rubble-stone masonry specimens. In the 2D-PM model the stone and mortar, elements are represented as particle assemblies that interact with each other, thus capable of representing their inherent material heterogeneity.

The validation of the 2D-PM models of the rubble stone-masonry specimens under uniaxial compression and combined shear-compression loading conditions is performed using the Parmac2D software. The presented results show that 2D-PM models are able to predict the crack propagation, the final failure mode, the maximum compressive and shear strength and the ductility observed experimentally.

Author Keywords. Structures, Rubble-stone masonry, Particle model, Uniaxial compression, Shear-compression.

ID: 69

Automatic project check based on BIM Objects

Renata Nunes Aguiar[1], João poças Martins[1,2]

[1]CONSTRUCT - Faculdade de Engenharia, Universidade do Porto, Porto, Portugal

[2]BUILT CoLAB – Collaborative Laboratory for the Future Built Environment, Porto, Portugal

Abstract

The purpose of this paper is to summarize the ways of approaching the "BIM Object" as the main element of automatic verification, automated compliance check or automated code check (ACC), comparing the models adopted for the association of the elements, identification methodologies and functionalities. A selection of 25 articles, published from 2018 to 2022 and available online, were reviewed to analyze how the object was treated, the resources used for recognition and analysis, as well as the programming tools and the results of the proposed verification. Overall, the publications presented valid tools, but were unable to check through a project completely, demonstrating the need for more evolved tools and processes. The involvement of stakeholders (suppliers, users and public authorities) also proves to be fundamental for the new proposals to adapt to real needs and thus gain conditions for use and development..

Author Keywords. automated code check (ACC), automatic verification, automated compliance check, BIM Object, Building Information Modelling (BIM), Civil Construction, Construction Materials.

ID: 103

From rural buildings to energy efficiency: the case study of Arundo Donax L.

Angelica Rocco[1]

[1]Diarc_Department of Architecture - University of Federico II, Via Forno Vecchio, 36, 80134 Neaples Italy (angelica.rocco@unina.it) ORCID 0000-0001-7213-4305

Abstract

In the construction sector, most of the energy is used for the production of materials, building construction, demolition and waste recycling, building environmental control and lighting. However, construction is one of the sectors with the greatest environmental impact considering than European buildings are responsible for 40% of the continent's energy consumption and 36% of greenhouse gas emissions.[1] The building industry must reduce its environmental impact through sustainable and bioclimatic design. The goal is NZEB - Nearly Zero Energy Building /zero emission buildings by 2050.

The aim of the research is to direct the construction sector towards a conscious use of resources with the use of bio construction materials, for example, starting from vegetable fiber materials. Thanks to the bio-renewable and recyclable properties, vegetable fibers can replace the use of synthetic fiber composites in various production sectors, however, the increase in the demand for raw materials leads us to make considerations on the vegetable fibers to be used for building materials: bast fibers are mainly produced in the Asian continent with very high environmental impacts linked to the transport of raw materials. A solution could be the choice of local raw materials such as agricultural waste or pruning waste to also preserve biodiversity: The use of local material in buildings reduces transport costs and environmental impacts, we can measure its future effects in rural buildings and it is easily recyclable because it returns to its environment.

Arundo Donax L. is an abundant plant on the European continent. it has been used for centuries for crafts and construction. “Incannucciata” vaults and attics are a typical example of its use in construction. The study starts from the search for examples of vernacular architecture of the “Incannucciata”, and the properties and strengths of cane fiber are presented. Further investigation with Geographic Information System (GIS) is conducted to understand the potential development of a building material based on Arundo Donax L.

Author Keywords. bio construction materials, Arundo Donax L, GIS, Incannucciata

ID: 114

Microstructure and hardness properties of a S690QL steel welded joint

Paulo Mendes[1], Mário Monteiro[2], Rui Pedro Silva[3], José A.F.O Correia[4], Abílio de Jesus[5], Manuel Vieira[6], Tiago Pereira[7], Ana Reis[8]

[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (pjmendes@fe.up.pt) ORCID 0000-0002-8588-4807

[2]Departamento de Engenharia Metalúrgica e de Materiais, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201806535@up.pt)

[3]INEGI - Instituto de Ciência e Inovação em Engenharia Mecânica e Gestão Industrial, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (rpsilva@inegi.up.pt)

[4]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (jacorreia@fe.up.pt) ORCID 0000-0002-4148-9426

[5]Departamento de Engenharia Mecânica, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ajesus@fe.up.pt) ORCID 0000-0002-1059-715X

[6]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (mvieira@fe.up.pt) ORCID 0000-0002-3667-0562

[7]MARTIFER SGPS, Zona Industrial, 3684-001, Oliveira de Frades, Portugal (tiago.r.pereira@martifer.com)

[8]INEGI - Instituto de Ciência e Inovação em Engenharia Mecânica e Gestão Industrial, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (areis@inegi.up.pt) ORCID 0000-0003-0256-1488

Abstract

Offshore structures, such as oil and gas platforms, wind turbines, and wave energy converters, are exposed to harsh environmental conditions and high-stress cyclic loading. Ensuring the reliability and safety of these structures is crucial, with the performance of welded joints being a key factor in maintaining structural integrity. Welded joints in offshore structures typically experience fatigue loading, leading to material damage and potential critical failure. This study focuses on accurately evaluating the fatigue performance of welded joints made from high-strength steel, specifically S690QL, to guarantee the long-term durability and safety of offshore structures. Rotating bending fatigue test specimens were prepared from butt-welded S690QL plates, including samples from the base material, heat-affected zone, and weld bead. The fatigue behavior of the welded joint was analyzed using S-N curves, and the hardness properties were assessed through Vickers hardness testing. Additionally, Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDS) was conducted to provide valuable insights into the design and performance of welded joints in offshore applications. Through the integration of various testing and analysis methods, this research strives to offer a thorough comprehension of the mechanical behavior and characteristics of welded joints subjected to fatigue loading. Acquiring this knowledge is crucial for ensuring prolonged reliability and safety of offshore structures.

Author Keywords. Structures, S690QL, Microstructure, High-strength steel, Welded joints, Vickers hardness testing, SEM-EDS analysis

ID: 117

Effect of Fatigue Accumulation Rules on Probabilistic Modelling of Riveted Bridge Connections

A. Mourão[1], J. Nuno Silva[2], C. Horas[3], J.A.F.O. Correia[4], T. Bittencourt[5], R. Calçada[6]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (amourao@fe.up.pt) ORCID 0000-0002-0871-8346

[2]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (jnsilva@fe.up.pt) ORCID 0000-0001-5756-1173

[3]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (claudiohoras@fe.up.pt) ORCID 0000-0002-9868-3270

[4]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (jacorreia@fe.up.pt) ORCID 0000-0002-4148-9426

[5]Escola Politécnica, Universidade de São Paulo, Av. Prof. Luciano Gualberto, 05508-010 São Paulo, Brazil (tulio.bittencourt@poli.usp.br) ORCID 0000-0001-6523-2687

[6]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruiabc@fe.up.pt) ORCID 0000-0002-2375-7685

Abstract

Fatigue is regarded as the principal cause of component and structural failure due to inadequate maintenance plans, increased traffic demands and lengthy exposure to environmental agents, among other factors.

Throughout Europe, some 200 000 metal bridges have been identified to be at risk, a figure which pales in comparison to the threefold increase in the United States. Ergo, trustworthy fatigue evaluations are crucial. Numerous approaches may be employed to estimate fatigue performance; nevertheless, the efficiency of such methods is reliant upon the concentration of stresses/strains, multiaxiality, etc., but also on a model's aptitude to incorporate multi-level loading scenarios.

Thereby, the subject of this investigation is the interaction between both the probabilistic analysis being used to derive the design fatigue curves for metallic riveted bridge connections as well as the fatigue accumulation rules used to compute the structure's fatigue performance. For this, several probabilistic methodologies based on the standards, 2- and 3-parameter probability density functions as well as the Markov-Chain Monte Carlo, were applied for this purpose.

Finally, a comparison between linear and non-linear fatigue accumulation rules for each of the previously mentioned design curves is made.

ID: 135

High reflective finishing coatings based on nanotechnology for optical improved façades

Rita Carvalho Veloso[1,2], Andrea Souza[2], Joana Maia[2], João Ventura[1], Rosário Veiga[3], Nuno M.M. Ramos[2]

[1]IFIMUP, Departamento de Física e Astronomia, Faculdade de Ciências, Universidade do Porto, Rua do Campo Alegre s/n, 4169-007, Porto, Portugal (up201001431@up.pt, joventur@fc.up.pt)

[2]CONSTRUCT-LFC, Departamento de Engenharia Civil, Faculdade de Engenharia da Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (andrea.souza@fe.up.pt, up504230@up.pt , nmmr@fe.up.pt)

[3]LNEC- Laboratório Nacional de Engenharia Civil, Av. Do Brasil, 101, 1700-066, Lisboa, Portugal (rveiga@lnec.pt)

Abstract

Using adaptive materials in façades, such as reflective nanomaterials that can reduce the amount of absorbed solar energy in buildings, can be a promising solution to moderate the urban heat island effects. By integrating these materials into dark finishing coatings for external walls, solar energy absorption can be reduced, resulting in significant energy savings and enhanced occupant comfort. Two types of nanomaterials, a commercial nanoparticle, and a synthesized nanocomposite, were incorporated into a dark commercial finishing coating for External Thermal Insulation Composite Systems (ETICS). The optical properties, surface degradation and bio-susceptibility were evaluated and compared to the non-doped coating, before and after exposure to accelerated aging tests. The results demonstrated that nanoparticle inclusion improves the optical properties and reduces degradation. Briefly, we observed an overall total reflectance increase for the two samples (15% and 20%) when compared to only 12% of the non-doped finishing coating, providing a similar visual aesthetic.

Author Keywords. Reflective Nanomaterials; Near-Infrared Reflectance; Dark coatings; Energy-efficient buildings; Building Construction.

ID: 140

Inclined plane shear behaviour of the interface between a recycled aggregate from construction and demolition waste and geosynthetics

Marisa Gomes[1], José Ricardo Carneiro[2], Castorina Silva Vieira[3]

[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201704990@edu.fe.up.pt)

[2]CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (rcarneir@fe.up.pt) ORCID 0000-0003-0552-4076

[3]CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cvieira@fe.up.pt) ORCID 0000-0001-6328-4504

Abstract

The building and construction sector is one of the main producers of waste. In order to achieve a more sustainable construction, it is essential to develop applications for construction and demolition waste (CDW), making it a valuable raw material. Existing solutions include, for example, the use of recycled aggregates from CDW in the base layers of transport infrastructures or as backfill material in structural embankments. The use of a combined CDW/geosynthetic system can be a viable option to construct stable slopes. Fitting in this last application, this work studies the inclined plane shear behaviour of the interface between a fine-grained recycled aggregate from CDW and geosynthetics. Inclined plane shear tests were carried out under different vertical confinement stresses and considering different degrees of compaction and moisture contents of the recycled aggregate from CDW. The inclined plane shear behaviour of the recycled aggregate from CDW was also characterised for comparison.

Author Keywords. Construction and demolition waste, waste valorisation, recycled aggregates, geosynthetics, inclined plane shear behaviour.

ID: 168

3D Reconstruction using Drones as a Tool for Energy Efficiency in Buildings - BIM to BEM

Leonardo Rodrigues[1,2,3,a], Diogo F. R. Parracho[4,b], Sara S. Freitas[1,c], João Poças Martins[4,5,d], Ana S. Guimarães[1], João M. P. Q. Delgado[1,f]

[1]CONSTRUCT-LFC, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal.

[2]LEPABE-Laboratory for Process Engineering, Environment, Biotechnology and Energy, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[3]ALiCE-Associate Laboratory for Innovation in Chemical Engineering, Department of Chemical Engineering, Faculty of Engineering, University of Porto, 4200-465 Porto, Portugal

[4]CONSTRUCT-GEQUALTEC, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal

[5]Built CoLAB – Collaborative Laboratory for the Future Built Environment, Rua do Campo Alegre 760, 4150-003, Porto, Portugal

[a]up201306124@edu.fe.up.pt ORCID 0000-0002-3228-6977; [b]dfrparracho@fe.up.pt ORCID 0000-0003-0413-6178; [c]up200606912@edu.fe.up.pt ORCID 0000-0002-1452-4986; [d]jppm@fe.up.pt ORCID 0000-0001-9878-3792; [e]anasofia@fe.up.pt ORCID 0000-0002-8467-6264; [f]jdelgado@fe.up.pt ORCID 0000-0002-1026-4523

Abstract

Building Information Modeling (BIM) is a digital tool to design, construct, and manage buildings. It has paved the way for the implementation of Building 4.0, which leverages technologies such as virtual reality and digital twins to improve building performance. Unmanned aircraft systems (UAS/drones) are becoming increasingly popular as a mean of gathering data from buildings. A methodology was developed for digitally integrate photogrammetric surveys of structures into BIM exclusively using these equipment. Nowadays, buildings account for 40% of all energy use in Europe; consequently, integrating BIM and BEM (Building Energy Modeling) is crucial to digitalize the construction industry and boost competitiveness through cost reduction. To show the value of drones for the energy-related optimization of solutions, this work describes a procedure for 3D reconstruction of a building using of one of the aforementioned aircrafts. Numerical simulations were conducted on the case study building and validated though comparison with experimental data.

Author Keywords. BIM, BEM, photogrammetric survey, sustainable construction, energy simulation, UAS, UAV, drones

ID: 194

Development and Validation of an Innovative Hinged System for the Conversion of Wave Energy in Coastal Structures

Giovanni Albarello Martins[1]

[1]Faculty of Engineering, University of Porto, Civil Engineering Department, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (jijomartins@gmail.com)

Abstract

The conversion of wave energy into usable energy has gained significant attention due to the increasing demand for sustainable energy sources, specifically within coastal structures. Wave energy theoretical potential is huge with recent estimations pointing to about 32000TWh per year. This study presents an innovative hinged system designed to convert wave energy into mechanical energy, generating electricity at the Port of Leixões. The system utilizes floating bodies that move up and down in response to wave motion, converting their movement into mechanical energy through a power take-off system. The paper provides a detailed description of the system's design and its key components. Results from validation tests conducted on a prototype demonstrate the feasibility and efficiency of the proposed hinged system. The paper also discusses the system's potential applications, limitations, and future research directions. This work contributes to ongoing efforts to develop sustainable methods for converting wave energy that can support renewable energy generation in coastal structures.

Author Keywords. Wave energy, Renewable energy, Clean energy, Point-absorbers, Marine resources, Energy Self-Sufficiency.

ID: 201

Evaluation of Air Cleaning using Functionalized Asphalt Mixture Sprayed with TiO_2 Nanoparticles

Élida Margalho[1], Orlando Lima Jr.[2], Iran Rocha Segundo[3], Clarisse Nunes[4], Carlos Tavares[5], Elisabete Freitas[6], Joaquim Carneiro[7]

[1]University of Minho, ISISE, ARISE, Department of Civil Engineering, Guimarães, Portugal and Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, Guimarães, Portugal. (eng.elidamelo@gmail.com) ORCID 0000-0002-6649-4029

[2]University of Minho, ISISE, ARISE, Department of Civil Engineering, Guimarães, Portugal and Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, Guimarães, Portugal. (orlandojunior.jr@hotmail.com) ORCID 0000-0001-5702-006X

[3]University of Minho, ISISE, ARISE, Department of Civil Engineering, Guimarães, Portugal and Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, Guimarães, Portugal. (iran@civil.uminho.pt) ORCID 0000-0002-4199-5994

[4]Energy and Geology National Laboratory, LNEG Campus Lumiar, Lisbon, Portugal. (clarisse.nunes@lneg.pt) ORCID 0000-0002-1715-3172

[5]Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, Guimarães, Portugal. (ctavares@fisica.uminho.pt) ORCID 0000-0001-5757-0096

[6]University of Minho, ISISE, ARISE, Department of Civil Engineering, Guimarães, Portugal. (efreitas@civil.uminho.pt) ORCID 0000-0001-5132-7407

[7]Centre of Physics of Minho and Porto Universities (CF-UM-UP), Azurém Campus, University of Minho, Guimarães, Portugal. (carneiro@fisica.uminho.pt) ORCID 0000-0001-9778-5390

Abstract

The toxic effects of air pollution on society and the environment have raised significant concerns. Pollutants, such as NO_x, are released into the atmosphere through road traffic, leading to acid rain and posing risks to human health. Using semiconductor materials, e.g., TiO_2, in Asphalt Mixtures (AM) to degrade NO_x, is a promising solution for mitigating the negative impacts of atmospheric pollution. Asphalt pavements have advantages for this functionalization, as they have an extensive area and are close to gases generated by vehicles. Thus, this investigation aims to evaluate the NO_x air cleaning promoted by the functionalized AM. For this, an asphalt mixture AC 10 was functionalized by spraying TiO_2 nanoparticles and then evaluated using a photoreactor under the standard ISO 22197-1. The results indicated a photocatalytic activity of the functionalized AM with potential air cleaning. It was possible to remove a net amount of at least 192 ppb of NO_x. submitting.

Author Keywords. smart asphalt mixture; photocatalytic asphalt mixture; TiO_2, air cleaning; NO_x removal efficiency

ID: 232

Algorithm development for out-of-roundness detection in railway vehicles

Vítor Gonçalves[1], Araliya Mosleh[2], Cecília Vale[3], Pedro Aires Montenegro[4]

[1]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (vtgoncalves@fe.up.pt) ORCID 0000-0001-6766-0407

[2]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (amosleh@fe.up.pt) ORCID 0000-0001-6751-0388

[3]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cvale@fe.up.pt) ORCID 0000-0003-2470-9834

[4]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (paires@fe.up.pt) ORCID 0000-0001-5699-4428

Abstract

The objective of this work is to identify defects in railway vehicle wheels by using an envelope spectrum analysis technique on data collected by a simulated wayside monitoring system situated on the track. In the simulations, three types of wheel flat profiles and three periodic polygonal wheel profiles are examined, along with results obtained from dynamic analyses conducted on wheels that are not damaged. Additionally, the simulation considers track irregularity profiles generated based on the Federal Railroad Administration. The dynamic responses of several strain gauges and accelerometer sensors located on the rail between sleepers are evaluated from the numerical calculations. Only the right wheel of the first wheelset is considered defective, but the detection methodology is effective for various damaged wheels located in any position. The application of the methodology demonstrates that the envelope spectrum analysis can successfully differentiate between healthy and defective wheels.

Author Keywords. Algorithm, numerical simulation, train–track interaction, validation, wheel out-of-roundness, wayside condition monitoring, wheel flat, polygonised wheel

ID: 238

Characterization of a Cement Mixture for 3D Printing

Gonçalo Martins[1], Pedro F. Pereira[1], Manuel Jesus[1], Ana Pessoa[1], Ana Mafalda Matos[1], Ana Sofia Guimarães[1], Bárbara Rangel[1]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201705655@fe.up.pt)

Abstract

During this research, the objective is to study the applicability of 3D printing in the construction sector and its correspondence with some Industry 4.0 goals. For this it was necessary to make a brief state-of-art regarding both topics, focusing on the existing 3D printing materials and techniques and what are the future challenges associated with this technology. To prove the possibility of applicability of these materials in the sector, several test pieces were printed in the laboratory using a cementitious mixture and a 3D printer, which uses the extrusion method, to then evaluate the properties of the test specimens printed using normative tests. For this, the test for the compression of the concrete and the traction of the concrete were used at the level of tests for the analysis of mechanical properties, while for tests thermally oriented analyzing the material, the capillarity and thermal conductivity test were used, and the mixture was also analyzed through the scattering test. For these values to have some scientific significance, normative tests were used to be possible to compare with other materials.

Author Keywords. 3D Printing, Industry 4.0, 3D Printing Techniques in Construction Industry, Cementitious Material, Mechanical Properties, Thermal Properties, Property Comparison.

ID: 239

Use of Construction and Demolition Waste in bituminous mixtures

Manuel Caló[1], Cecília Vale[2]

[1]CONSTRUCT-LESE, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (mjcalo@fe.up.pt) ORCID 0000-0001-9455-8774

[2]CONSTRUCT-LESE, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (cvale@fe.up.pt) ORCID 0000-0003-2470-9834

Abstract

To minimize the negative impacts on the environment with the production of aggregate for the manufacture of bituminous mixtures, it is recommended to replace them, totally or partially, with another type of material, such as, for example, Construction and Demolition Waste - CDW, which contribute positively to the 3Rs policy: reduce, reuse and recycle.

CDW, when selected, is often traded in many types like recycled concrete aggregates (RCA), brick masonry aggregates with or without mortar, ceramic aggregates or recycled bituminous mixes (RAP). These selected materials undoubtedly offer greater quality and constancy in their characteristics compared to the unselected CDW. This is however the material proposed to be studied as an aggregate, seeking to know, depending on the constituents and their characteristics, which actions to take in order to replace the highest possible percentage of natural aggregate for a hot bituminous mixture.

Prior to its application, it is necessary to know their geometric, physical and chemical properties, as per the European Standard EN 13043. In addition to these properties, an essential test which is not referred to in this standard is that of "identifying and estimating the relative proportions of the constituent materials", which is carried out in accordance with the European Standard EN 933-11 standard. CDW generally consists of a greater or lesser variety of materials such as: concrete, concrete blocks, mortar ($\mathbf{R_c}$), unbounded aggregates, natural stone, aggregates with mortar ($\mathbf{R_u}$), brick or ceramic aggregates ($\mathbf{R_b}$), bituminous materials ($\mathbf{R_a}$), glass ($\mathbf{R_g}$), cohesive materials: soil and clay, and other materials like plasterboard, stucco, asbestos, oil, metals, plastic, non-floating wood, glue, paint, paper, insulation ($\mathbf{X}$) and floating materials ($\mathbf{FL}$). The work carried out observes that unselected CDW is a material whose heterogeneity of constituents has consequences on the geometric, physical and chemical characteristics of the aggregate and on the structural response of the compacted course.

From the literature review, it appears that the non-selected CDW has some negative characteristics, such as poor grading, excess of fine material and oversized elements, high porosity and absorption, lower mechanical resistance of brick and ceramic , lower angularity and roughness. Therefore, with negative effects on bituminous mixtures compared to those consisting only of natural aggregates. In addition, the smooth faces of brick fragments, often covered with fine material, and high acidity elements negatively affect the affinity for the binder. The inability to maintain the original characteristics of the structure of the aggregate results more from the presence of recycled elements than from stone.

There are, however, processes to improve the characteristics of these aggregates and therefore the behavior of the bituminous mixture, like for example: the identification and removal of undesirable constituents, the granulometric selection of particles and surface treatments such as strengthening or removing mortar surfaces adhered to the recycled aggregate.

ID: 244

New sensor technologies applied to dynamic monitoring of railway bridges

Chanalisa Salvi[1], Carlos Moutinho[2]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201609850@fe.up.pt) ORCID 0000-0003-2312-9192

[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (moutinho@fe.up.pt) ORCID 0000-0001-9448-24663Ixxxxxxx

Abstract

Given the current obstacles in monitoring, particularly related to cost, since measuring bridge responses in the field is usually expensive and challenging, while also requiring a high effort for maintenance, it is of great value to provide a monitoring system that overcomes the disadvantages of classical solutions. In view of this, the main objective of this research was to develop a structural monitoring system with the use of custom sensors, applied to a railway bridge located in Portugal. The intention is to prove the advantage of these sensors, through their cost, robustness, autonomy and effectiveness. Furthermore, the development of numerical models supported by relatively inexpensive instrumentation becomes an effective tool in dynamic analysis and in the knowledge of important parameters of the structure. The preliminary results obtained by the environmental vibration test, besides validating the sensors, allowed to calibrate the numerical model and to verify the real traffic loads.

Author Keywords. Steel Railway Bridge, New sensors, Identification of dynamic parameters, Numerical model, Traffic characterization.

ID: 294

Identification of vulnerable zones to erosion along the Caminha-Espinho coastal stretch based on recent shoreline evolution

Bernardo Martins[1], Francisco Taveira Pinto[1], Paulo Rosa Santos[1], Luciana das Neves[1]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (up201603454@edu.fe.up.pt) ORCID 0000-0001-8296-4329; (fpinto@fe.up.pt) ORCID 0000-0003-4337-8428; (pjrsantos@fe.up.pt) ORCID 0000-0002-3768-3314; (lpneves@fe.up.pt) ORCID 0000-0002-7876-6423

Abstract

Shoreline dynamics result from the interaction between the sea and the land being influenced by both natural and anthropogenic factors. Coastal zones are under increasing pressure due to population growth and climate variability, that is expected to aggravate under climate change impacts.

In this study, vulnerable zones to erosion are identified based on satellite-detected shorelines. It also provides a quantitative and qualitative analysis of the shorelines' evolution over a long period.

The obtained data is then compared with reference values from coastal planning instruments. This comparison with reference values provides a validation of the analysis results and allows to confirm erosive trends in previous studies and update them with more recent observations from a different, more extended time period.

In total, thirteen vulnerable areas to erosion were identified in eight of the sixteen defined sectors along the Caminha-Espinho coastal stretch.

Author Keywords. Hydraulics; Water Resources and Environment; Shoreline; Vulnerable Zone; Satellite Imagery; CoastSat; Digital Shoreline Analysis System.

ID: 295

ISBN: 978-972-752-313-9

www.fe.up.pt/dce
dce@fe.up.pt