DCE 19 3rd DOCTORAL CONGRESS IN ENGINEERING

DOCTORAL CONGRESS in ENGINEERING

Book of Abstracts

3rd Symposium on Civil Engineering and Spatial Planning

U.PORTO
FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

DCE 19 3rd DOCTORAL CONGRESS IN ENGINEERING

Book of Abstracts

of the

3rd Symposium on Civil Engineering and Spatial Planning

Editors:
Humberto Varum, Isabel Breda Vázquez, Nuno Ramos,
Andreia Meixedo, Catarina Cadima, Jorge Gonçalves

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This volume contains the abstracts presented at the Symposium on Civil Engineering and Spatial Planning, within the 3rd Doctoral Congress in Engineering - DCE19, held in Porto, between June 27th and 28th, 2019.

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Edited by Humberto Varum, Isabel Breda Vázquez, Nuno Ramos, Andreia Meixedo, Catarina Cadima, Jorge Gonçalves

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Symposium on Civil Engineering and Spatial Planning

Chairs: Humberto Varum, Isabel Breda Vázquez & Nuno Ramos
Location: B021 and B022
Time for oral presentation: 10 min + 3 min discussion

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- Hugo Lopes, APDL
- João Carvalho Mendes, Grupo Águas de Portugal
- Mário Marques, Sonae

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- Joaquim Poças Martins, OERN
- Luís Silva, Saint-Gobain Weber
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Envelope systems with high solar reflectance by inclusion of nanoparticles

EnReflect is an FCT Project headed by CONSTRUCT-LFC from FEUP and IFIMUP from FCUP, with cooperation of Saint-Gobain Weber.

The implementation of high solar reflectance solutions in building envelopes increases their energy efficiency and the Durability of envelope solutions. This is an important step to meet the NZEB goal set by the Energy Performance of Buildings Directive 2010/31/EC.
The main goal of EnReflect is to re-design envelope systems by increasing their solar reflectance using nanotechnology.
The main idea is to fabricate, using a green synthesis approach, novel nano-materials with high NIR reflectance by bandgap engineering to apply to typical envelope systems.

This Workshop will consist in the presentation of the EnReflect project to the scientific and academic community and will be divided in 3 distinct parts:

1. Eng. Luís Silva (Saint-Gobain Weber): The perspective of the construction industry – The importance of thermal improved façades with inclusion of high reflectance particles;
2. Dr. João Ventura (IFIMUP-FCUP: The perspective of Physics and Nanotechnology Sciences – The influence of different nanoparticles in the reflectance of façade coatings;
3. Prof. Nuno Ramos (CONSTRUCT-LFC): The perspective of Building Physics – Aesthetics vs. energy efficiency vs. Durability

The Workshop will be concluded with a debate and a demonstration of the nano-materials in specific finishing materials applied in building.

ORAL PRESENTATIONS

Topic: Structures Technical Session I-A (27th.June)

ASSESSMENT OF THE LONG-TERM DYNAMIC BEHAVIOR OF INNOVATIVE RAILWAY TRACK SOLUTIONS. # 254

Ana Luísa Ramos[1], António Gomes Correia[2] , Pedro Alves Costa[3] , Rui Calçada[4]

1Departmento de Engenharia Civil, Escola de Engenharia, Universidade do Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (id6629@alunos.uminho.pt)
2Escola de Engenharia, Universidade do Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (agc@civil.uminho.pt)
3Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (pacosta@fe.up.pt)
4Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ruiabc@fe.up.pt)

Abstract

The study and "assessment of the long-term dynamic behavior of innovative railway track solutions" pretends to understand the performance of railway systems and compare the long-term performance of the ballasted and slab tracks, mostly in transition zones. This study can help in the prediction and control of the long-term behavior of railway structures, which can lead to a reduction in the operations and maintenance costs, through the implementation of innovative solutions with impact on the whole system.

Author Keywords. ballasted and slab tracks, numerical model, long-term performance.

DAMAGE IDENTIFICATION BASED ON DYNAMIC INDICATORS OF THE TRAIN-BRIDGE SYSTEM. #137

Andreia Meixedo[1], Diogo Ribeiro[2], João Santos[3], Rui Calçada[1]

1Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ameixedo@fe.up.pt, ruiabc@fe.up.pt)
2Departamento de Engenharia Civil, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida, nº431, 4249-015 PORTO, Portugal (drr@isep.ipp.pt)
3Laboratório Nacional de Engenharia Civil, Avenida do Brasil, nº101, 1700-066, Lisboa, Portugal, (josantos@lnec.pt)

Abstract

The maintenance of bridges is central to the structural integrity and cost-effectiveness of any transportation system and therefore early damage detection plays a central role in any maintenance program (Carey et al.,2013). However, in the case of railway infrastructures, their intense use by frequent and heavy traffic makes the task of detection and possible repair of damaged sections problematic. Additionally, although most bridges are assessed via periodical visual inspections, they are expensive, scattered in time and prone to error, which allows to vibration-based SHM techniques to emerge, mainly on large newly built bridges (Cantero & Base, 2015). Early warning systems that minimize the disruption of the network are desirable and useful (Huang et al., 2012).

This work aims at applying vibration-based damage-identification methodologies capable of automatically extracting meaningful information related to the railway bridges' condition, from the great amounts of SHM data acquired

nowadays from monitored structures. The idea is to take advantage of the fact that vehicles of known axle configuration cross the bridge regularly, that normally only one train is on the bridge at a time and that the relative positioning of the loads does not change. Additionally, it is important to develop a methodology able to detect damage based on responses that can be measured without interfering with the normal service condition of the structure (Obrien, 2013).

The revision of the SHM literature has allowed concluding that the SHM techniques, which are more appropriate to fulfill this goal, are those based in statistical learning, particularly the forward SHM techniques (Farrar. & Worden, 2013, Santos, 2014). In this sense, robust and adaptive algorithms for damage sensitive features extraction and selection based on autoregressive models are being developed, as well as techniques for feature classification. Specifically, the performance of the AR models as damage-sensitive features extractors is evaluated by applying these models to a several accelerations and displacements responses measured and simulated.
In order to identify damage based on the bridge responses during the train passage, an on-line monitoring system was installed at the railway bridge over the River Sado. The system aims at accomplishing a cost-efficient on-line SHM covering the majority of the structure's vulnerabilities by measuring accelerations, displacements, strains and temperatures. Given the goal of a real-time and continuous SHM, in addition to the network sensors, the hardware and software components were carefully defined. The long-term information obtained allows the validation of the methodology developed with a real-world case study.

With a calibrated numerical model of the railway bridge over the Sado River, different single and multi-damage scenarios are being simulated, with different levels of severity and in different locations. The damage identification methodology is being applied considering the bridge response with a single Alfa Pendular train travelling on the bridge deck, simulated by moving loads. In this sense, the numerical model of the bridge is being used to define the SHM system properties, to confirm the usefulness of the AR models to extract damage-sensitive features and to evaluate the classification performance of the techniques based on outlier analysis and ANN algorithms.

Author Keywords. Structural Health Monitoring, damage detection, dynamic performance indicators, autoregressive models, train-bridge system, soft computing

AN INNOVATIVE BRIDGE MANAGEMENT SYSTEM: APPLICATION TO A PORTUGUESE RAILWAY BRIDGE. #250

João Fernandes[1], José C. Matos[1], Daniel V. Oliveira[1], António Abel Henriques[2]

[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (id5709@alunos.uminho.pt)
[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (jmatos@civil.uminho.pt)
[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (danvco@civil.uminho.pt)
[2] University Porto, CONSTRUCT, Faculty of Engineering, Porto, Portugal (aarh@fe.up.pt)

Abstract

Bridges are one of the most important assets on the railway infrastructures. In Portugal, IP- Infrastruturas de Portugal is the company responsible to manage the railway infrastructures of Portugal. Along their lifetime, infrastructures are subjected to several degradation processes that may compromise their functionality. Therefore, it is necessary to establish management strategies to keep their

functionality, but considering the budgetary constraints. In this extended abstract, it is intended to exemplify an application of a bridge management system (BMS) of a railway bridge in Portugal with a brief discussion of all the modules composing a management system.

Author Keywords. Bridges, Deterioration Models, Maintenance and Rehabilitation, Optimization.

A NOVEL APPROACH FOR THE CONDITION MONITORING OF A FREIGHT WAGON. #266

José Neto[1], Pedro Montenegro[1], Rui Calçada[1]

[1]Construct, Department of Civil Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (up201002903@fe.up.pt; paires@fe.up.pt; ruiabc@fe.up.pt)

Abstract

Ensure a safe environment and a continuous sustainable operation system are key aspects for rail administrations and rolling stock companies. The schedule preventive interventions that are mandatory by the norms lead, in a significant number of times, to the replacement of fully functional components and, consequently, to unnecessary expenses. Furthermore, infrastructure managers are currently relying on inspection cars to assess the track geometry quality, leading to unnecessary constraints for the operation service administrators. Alternatively, these undesired restraints can be mitigated with the implementation of an on-board monitoring system in in-service vehicles. It is a reliable and non-invasive system capable of identifying both track and train operation conditions.

This paper starts with a short explanation of the developed monitoring system. It was implemented on an in-service freight wagon that operates in the Beira Alta line, collecting over 200km of data information. Then, a brief description of the numerical models of the track and the freight train are presented. Subsequently, the vehicle-track interaction problem is solved and the responses are compared with the experimental ones. The comparison results revealed a high level of accuracy, even before the calibration process. Finally, an inverse dynamic model is proposed and applied to the numerical problem, showing good results regarding the prediction of the wheel-rail interaction forces.

Author Keywords. Condition monitoring, inverse model, wheel/rail contact forces, on-board monitoring systems

NUMERICAL ASSESSMENT OF THE STRUCTURAL BEHAVIOUR OF TWO STONE MASONRY ARCH BRIDGES UNDER RAILWAY LOADING. #150

Rúben Silva[1], Cristina Costa[2], António Arêde[3]

1CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal (up201607996@fe.up.pt) ORCID 0000-0002-5809-7971
2CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal and Polytechnic Institute of Tomar, TOMAR, Portugal (c.costa@ipt.pt)
3CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal (aarede@fe.up.pt)

Abstract

In this paper is presented a numerical strategy for the structural assessment of existing railway masonry bridges. This strategy is based on continuous homogeneous finite element models, where an equivalent continuum is defined with characteristics that allow the description of the global behavior of the masonry components as a composite material. A Drucker-Prager model is adopted for the simulation of the nonlinear behaviour of both masonry and infill material. This structural assessment strategy is applied to two case study bridges, comprising the numerical assessment of their load-carrying capacity.

Author Keywords: Stone masonry bridges, railway loading, material parameters, FE numerical modelling

NON-DESTRUCTIVE ASSESSMENT METHOD FOR STONE MASONRY USING ANN. #148

Rachel Martini[1], Jorge Carvalho[2], António Arêde[3], Humberto Varum[4]

1PhD student, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto, Rua Dr.Roberto Frias, 4200-465 PORTO, Portugal (martini.rachel@fe.up.pt) ORCID 0000-0002-2639-0532
2Assistant Professor, CERENA – Faculdade de Engenharia, Universidade do Porto, Rua Dr.Roberto Frias, 4200-465 PORTO, Portugal (jorcarv@fe.up.pt) ORCID 0000-0001-6615-9872
3Associate Professor, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto,Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (aarede@fe.up.pt) ORCID 0000-0002-0901-2214
4Full Professor, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto, Rua Dr.Roberto Frias, 4200-465 PORTO, Portugal (hvarum@fe.up.pt) ORCID 0000-0003-0215-8701

Abstract

This work contributes to deepen the technical-scientific knowledge regarding the characterization of granite masonry based on geophysical, mechanical and neural networks techniques. For this purpose, a methodology based on non-destructive tests was used to characterize historical masonry and later to obtain information regarding the mechanical parameters of these elements. A mechanical characterization tool was developed resorting to Artificial Neural Networks (ANN). The database for the characterization was built using GPR, sonic and dynamic test results. The mechanical characterization was done by means of conventional uniaxial compression tests. For the construction and choice of the network architecture, 31 possible combinations of input data were defined, with a total of 122 trained networks. From all trained ANNs, based on the errors attributed to the estimated moduli of elasticity, networks with acceptable errors of up to 30% were selected.

Author Keywords. sonic test, dynamic test, GPR, compression test, artificial neural networks

Topic: Geotechnics Technical Session I-B (27th.June)

RAILWAY BALLAST BEHAVIOUR OF INERT STEEL SLAG AGGREGATE UNDER MONOTONIC AND CYCLIC TRIAXIAL LOADING. #146

Bruno Delgado[1], António Viana da Fonseca[2], Eduardo Fortunato[3]

[1]CONSTRUCT-Geo, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (brunogdelgado@hotmail.com)
[2]CONSTRUCT-Geo, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (viana@fe.up.pt)
[3]Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal (efortunato@lnec.pt)

Abstract

In the 21st century the environmental concerns have imposed new approaches to use of natural resources. Especially in Civil Engineering, the rational use of natural resources imposes itself as a new paradigm for conception, design and construction, justifying the research for alternative materials to those conventionally used in the railway industry, such as natural crushed rocks, for example.

This work presents the results of monotonic and long-term cyclic triaxial tests carried out on scaled down ballast specimens in a ratio of 1:2.5 from the ballast standard AREMA N. 24 (AREMA 2013). The mechanical behaviour of an inert steel slag ballast and of a granite ballast were compared. The cyclic tests were conducted in two different stress paths compatible with heavy haul loading. The steel slag ballast presented higher values of shear strength parameters and better deformability behaviour, expressed by higher values of resilient modulus, lower particle breakage, and a faster tendency for permanent deformation stabilization.

Author Keywords: Railway ballast behaviour, Triaxial tests, Steel slag ballast, Heavy haul loading.

CYCLIC LIQUEFACTION RESISTANCE FROM IN SITU AND LABORATORY TESTS: MODELLING CALIBRATION FOR NUMERICAL APPLICATIONS. #167

Catarina Ramos[1], António Viana da Fonseca[2], Matthew Coop[3]

[1]CONSTRUCT-GEO, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (catarinacorreiaramos@gmail.com) ORCID 0000-0001-6679-8121
[2]CONSTRUCT-GEO, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (viana@fe.up.pt) ORCID 0000-0002-9896-1410
[3]University College London, UK (m.coop@ucl.ac.uk)

Abstract

Earthquakes have been responsible for many human casualties and resulted in high economic and social damage. One phenomenon associated to this natural disaster is the liquefaction of soils, which can have devastating consequences. The purpose of this work is to deepen the studies in cyclic liquefaction as it is a problem of great importance especially when considering non-consensual factors. This study focuses on soils from an experimental site located in Lezíria Grande de Vila Franca de Xira, Portugal. The interpretation of a soil profile

based on SPT and CPTu is presented and the laboratory work performed is briefly discussed.

Author Keywords. Liquefaction, in situ tests, laboratory tests.

STABILIZATION OF SEDIMENTS WITH GEOPOLYMERS FOR FOUNDATION OF COASTAL AND FLUVIAL STRUCTURES. #109

Claver Pinheiro[1], Sara Rios[2], Nuno Cristelo[3], António Viana da Fonseca[4]

[1]CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (clavergiovanni@gmail.com) ORCID 0000-0002-0402-1357

[2] CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (sara.rios@fe.up.pt) ORCID 0000-0002-2625-1452

[3]Departamento de Engenharias, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, 5000-801, Vila Real, Portugal (ncristel@utad.pt) ORCID 0000-0002-3600-1094

[4] CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (viana@fe.up.pt) ORCID 0000-0002-9896-1410

Abstract

The development of techniques currently used to increase the bearing capacity such as Deep Soil Mixing (DSM) makes possible the construction activity in places where the soil has weak geomechanical characteristics. However, this ground improvement techniques use large amounts of Portland cement (PC). For this reason, the number of research studies about the use of waste materials for soil improvement has increased. The alkaline activation (AA) technique can be very interesting for that purpose as it uses waste materials such as slags and fly ash. In comparison with cement-based binders, alkali activated binders (AA binders) have proved its technical and economic viability (Cristelo et al., 2012a; 2012b), but their application in specific conditions still needs to be studied. AA binders are expected to have lower cost-benefit ratio when used in contaminated or salted sediments when compared to PC grouts.

Thus, the aim of this research is to develop an alkali activated binder made of steel slag instead of PC, to be used in Deep Soil Mixing columns in coastal areas. The slag is mixed with an alkaline solution made with sodium hydroxide and sodium silicate creating a gel that binds the particles together and hardens with time. The first step of this research was the optimization of the binder using the Design of Experiments (DoE) methodology to maximize the mechanical resistance and to minimize their cost. The soil characterization with Cone Penetration Test (CPTu) and laboratorial tests (consolidated drained (CD) and consolidated undrained (CU) triaxial tests, grain size distribution and specific gravity) was carried out to understand the soil behaviour when mixed with the binder. The next step was to optimize the mixture of the binder with the soil, in terms of solids/liquid ratio and concentration of the alkaline solution. Then, the mechanical performance of the treated soil in the DSM columns was evaluated by simulating its properties in the laboratory following the EuroSoilStab (2002) precepts. Initially this was analysed by flexural and compressive strength tests in specimens cured under salt water. The curing under water has a major effect on this material before its hardening due to the removal of the silica gels during the curing time. The effect of curing under stress was evaluated by triaxial compression tests, which is important due to the columns height. The short-term behaviour was assessed by mini-Vane tests and Fall Cone Tests to evaluate the immediate strength and workability of the mixture.

Author Keywords: Deep Soil Mixing, Alkaline Activation, Soil Improvement

STRESS-STRAIN BEHAVIOR FROM TRIAXIAL TEST ON GEOGRID-REINFORCED AGGREGATE-SOIL INTERFACE SPECIMENS. #57

Gabriel Marchi[1], Isabel Falorca[2]

[1]C-MADE, Departamento de Engenharia Civil e Arquitetura, Faculdade de Engenharia, Universidade da Beira Interior, Calçada Fonte do Lameiro, 6200-358 COVILHÃ, Portugal (gabriel.marchi.oliveira@ubi.pt) ORCID 0000-0001-8800-285X [2]C-MADE, Covilhã, Portugal, (ifalorca@ubi.pt) ORCID 0000-0002-6681-2525

Abstract

The behavior of basal reinforced fills depends largely on the mechanical properties at the geogrid-reinforced aggregate-soil interface. These properties are derived through analysis and interpretation of deformation and load measurements during tests. Depending on the stiffness heterogeneity of the specimens, the deformed shape changes, and this is not typically considered when processing triaxial test data. Therefore, the approaches currently used to obtain stress-strain relations from triaxial compression test need more advanced knowledge of mechanics. This paper describes the equilibrium configuration of geogrid-reinforced aggregate-soil interface specimens under axisymmetric compression conditions and outlines a procedure for processing test data. The standard method is considered satisfactory for estimating stiffness gain with the reinforcement addition, since the initial height of the specimen is corrected using a method of homogenization.

Author Keywords. triaxial test, soil-geosynthetic interaction, basal reinforced fills

STRUCTURAL MODAL ANALYSIS THROUGH WAVELET DECOMPOSITION OF AMBIENT VIBRATIONS AND THE HILBERT SPECTRUM. #14

Manuel Hormazábal[1], Francisco Fernández[2], Alejandro Rincón[2]

[1] Institute for Sustainability and Innovation in Structural Engineering (ISISE), School of Engineering, University of Minho, Campus de Azurém, 4800-058, Guimarães, Portugal. [2] Department of Mechanical Engineering and Industrial Design, School of Engineering, University of Cádiz, Av. Universidad de Cádiz 10, 11519, Cádiz, Spain.

Abstract

Conventionally, empirical modal analysis requires a known external excitation for a correct identification of the structure´s modal response. Due to this, most field testing must be done under controlled conditions in order to minimize the influence of unknown ambient excitations. Nevertheless, on public structures or service installations, as highway or railway bridges, it is not possible to stops the structure standard operation and they must be tested using ambient vibrations responses as output only measured data, known as Operational Modal Analysis (OMA). This essay investigates on experimental methods for operational modal frequency identification of large structures, based on discrete Wavelet packet decompositions of ambient vibrations measurements and post analysis on time and frequency domain through Hilbert spectrum. Comparison of results obtained with other methods will also be done. FEM model as a theoretical reference, LSCE and

4SID modal identification as empiric method references, and Hilbert-Huang Transform as experimental spectral reference method™™.

Author Keywords. Operational Modal Analysis, Structures Dynamics, Hilbert transform, Wavelet decomposition.

Topic: Structures Technical Session II-A (27th.June)

ROTATION CAPACITY OF STEEL MEMBERS UNDER CYCLIC LOADING #161

Anis Mohabeddine[1], J.A.F.O.C Correia[1], J.M Castro[1]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto

Abstract

The rotation limits of steel members are key modeling parameters and acceptance criteria for nonlinear analysis and performance assessment of steel moment-resisting frames. The rotation limits defined in Part 3 of Eurocode 8 (EC8-3) have been subject to a lot of discussion in the literature. This paper presents a numerical study on IPE steel beams subjected to cyclic loading. An advanced numerical model was developed in ABAQUS that accounts for the geometrical imperfections and is based on a comprehensive calibration of the material constitutive model. New rotation limits for the life safety limit state defined in EC8-3 are proposed. An empirical formulation based on regression analysis is derived for the evaluation of the rotation limits for different IPE sections.

Author Keywords: Rotation capacity, cyclic, IPE sections.

ASSESSMENT OF A RAILWAY BRIDGE DAMAGED UNDER FLOOD EFFECTS USING A ROBUSTNESS-BASED APPROACH. #235

Edward Baron[1], Jose Matos[2], Rui Calçada[3]

1School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (id8033@alunos.uminho.pt)
2School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (jmatos@civil.uminho.pt)
3School of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruiabc@fe.up.pt)

Abstract

One of the main goals of the iRail PhD program is the asset management of high capacity structures with accuracy and reliability. To achieve this principal objective, it is defined as a priority the innovation of methods to determinate the safety and extend the service life of rail infrastructures (i.e. railway tracks, bridges). Due to the importance of railway bridges for the network, it is necessary to assess the associate risk against natural hazards. This research consists in the assessment of flood effects (e.g. Scour) into the rail infrastructure. To achieve this, it is proposed a set of damage scenarios are introduced into a specific railway bridge typology. Thus, the outcome of the selected scour damages is computed using a robustness index, calculated by the variance of the structural reliability index due to the damage caused by the scour, allowing to quantify its impact in the structural safety. Namely a robustness-based approach assessment. Besides, the modelling process and the finite element analysis of the structure is performed using DIANA FEA software that allows the performance of probabilistic analysis based on non-linear behaviour of

the structure. Thus, it will be established as a part of the general framework basis for quality control and damage identification for this specific hazard

Author Keywords. Robustness, Scour, Railway bridges, Flood effect

DESCRIPTION OF A MONITORING CAMPAIGN IN AN ONSHORE WIND TURBINE IN TOCHA WIND FARM. #279

João Pacheco[1], Filipe Magalhães[1], Carlos Moutinho[1], Silvina Guimarães[3], Luís Noites[3], Álvaro Cunha[1], Miguel Marques[2] and José Carlos Matos[2],

1Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal
2Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal
3INEGI, Porto, Portugal

Abstract

In the context of the WindFarmSHM project a quite extensive experimental campaign is being performed in Tocha wind farm, an onshore wind farm located in Portugal. This includes the instrumentation of at least two wind turbines aiming the development, validation and optimization of monitoring strategies at the level of the wind farm for damage detection and fatigue analysis, using the response to operation loads measured by strain gages and accelerometers distributed in the tower and blades. The paper presents the experimental layout for one of the instrumented wind turbines, introduces the processing tools under development and shows some initial results. At this preliminary stage, it will be evaluated the ability of the different monitoring components to track the modal parameters of the system composed by the tower and the rotor.

Author Keywords. Wind Turbine, Dynamic Monitoring, Operational Modal Analysis.

WAVE PROPAGATION IN ELASTIC CABLES: NUMERICAL SIMULATION AND ASSESSMENT OF DISPERSIVE BEHAVIOR. #173

João Rodrigues[1], Elsa Caetano[2], João Santos[3], Maria do Carmo Coimbra[4]

1CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jmcr@fe.up.pt)
2CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ecaetano@fe.up.pt)
3Structural Monitoring Unit, Structures Department, National Laboratory for Civil Engineering, Avenida do Brasil, 101, 1700-066 LISBON, Portugal (josantos@lnec.pt)
4LSRE-LCM, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (mcoimbra@fe.up.pt)

Abstract

The dynamic behavior of cables is usually analyzed by superposition of vibration modes. However, this methodology becomes ineffective when the wavelength of cable response is small relative to its length. In this study, a wave propagation model for elastic sagging cables is considered, and the corresponding system of partial differential equations is solved by the method of lines, allowing the characterization of coupled longitudinal and transverse deflections in finite, real

cables. The numerical results thus obtained are used to compute time-frequency distributions in different sections along the cable length, permitting the assessment of dispersion relations for transverse group velocities.

Author Keywords. Cable dynamics, wave propagation, dispersion, partial differential equations, time-frequency analysis

AN OBJECT-ORIENTED BAYESIAN NETWORK MODEL FOR MAINTENANCE SYSTEM SELECTION IN STRUCTURES. #147

Sadegh Lajevardi[1] and José Matos

[1]Department of civil engineering, Faculity of engineering, Universidade do Minho, The campus of Azurem, 4800-058, Guimaraes, Portugal (Sadegh.lajevardi@gmail.com) ORCID 0000-0001-8405-8872

Abstract

Recent maintenance method development prepare many tools to manage project during operation. Meanwhile serious task to be made once a structure safe during operation is defined is the selection of maintenance method for various structure elements. To compare maintenance method with regard to decision criteria and the classified defect of structure's component, this paper presents an approach for decision making process in an object oriented model, in which each structure component is modeled with various possible alternative maintenance methods as an object. The uncertainty and defect probability combine with expert knowledge to find each maintenance method effects regarding the attributes of their component. This multi-criteria-decision-making deal with the essential imprecision of subjective judgment. To demonstrate the use and capability of the model, a case study is presented.

Author Keywords. Object oriented, Bayesian network, maintenance method, Risk assessment, Quality control.

Topic: Spatial Planning Technical Session II-B (27th.June)

URBAN DEVELOPMENT POLICIES AND INSTRUMENTS IN CONTEXTS OF FINANCIALIZATION. #152

Cláudia Affonso[1], Emília Malcata[2]

[1]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (a.claudiaaffonso@gmail.com)
[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (emalcata@fe.up.pt)

Abstract

This communication discusses the role of land value capture and large-scale urban development projects (UDPs) in promoting financialization processes. It also looks into how municipalities deal with these processes in order to further their agendas. In urban planning, financializing policy instruments are those that, to finance the built environment, promote institutional arrangements that adapt to the needs of the property market, the financial market, and to their interdependencies and dynamics. These instruments reflect a political and sociotechnical evolution that fostered the conversion of property, as physical and tangible space, into 'quasi-financial' assets that commodify space. UDPs correspond to the stage where commodification of land occurs and financialization takes place; they are often funded through land value capture instruments which, in some cases, can both be financialized and prone to develop financialization processes. However, if municipalities are prepared to deal with these processes it's a question that needs further clarification.

Author Keywords. land value capture, large-scale urban development projects, financialization, financializing policy instruments.

TRANSPORTATION, SUSTAINABILITY AND MOBILITY JUSTICE. #90

Isabel Cunha[1] , Cecília Silva[2]

[1] Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (isabelcunha@fe.up.com) ORCID 0000-0001-6566-9336
[2] Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ccsilva@fe.up.com) ORCID 0000-0003-2868-1840

Abstract

Changing the current mobility patterns by creating both public transport oriented and non-motorized development envisage a transition in the Transportation System's governance to achieve the expected sustainable and social performance. In this context, there are crucial gaps within the sustainable strategies and transportation planning which may perpetuate spatial and social inequalities in metropolitan areas. Thus, the present research presents a critical framework to assess to what extent the bicycle strategic planning can guarantee both accessibility and mobility justice in the sustainable mobility pathway.

Author Keywords. Sustainable mobility, Mobility justice, Equity, Bicycle, Metropolitan regions.

THE POTENTIAL OF BIKE SHARING IN INCREASING SUSTAINABLE MOBILITY IN CITIES. #61

João Filipe Teixeira[1], Cecília Silva[2], Frederico Moura e Sá[3]

[1]Research Centre for Territory, Transports and Environment (CITTA), Faculty of Engineering of the University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ega11021@fe.up.pt) ORCID 0000-0002-0948-9389
[2]Research Centre for Territory, Transports and Environment (CITTA), Faculty of Engineering of the University of Porto, (ccsilva@fe.up.pt) ORCID 0000-0003-2868-1840
[3]Centre for Studies in Governance, Competitiveness and Public Policies (GOVCOPP), University of Aveiro, (fredericomsa@ua.pt) ORCID 0000-0003-3660-2751

Abstract

In the last years, there has been a growing importance of cycling in the political arena, namely through the implementation of bike sharing systems (BSS). However, the role of BSS as a sustainable urban transport remains unclear, with an overall lack of research assessments and limited evidence on its ability to effectively induce modal shift from car to cycling.

This research objectives are twofold. First, to develop a methodology to assess car modal shifts due to BSS, considering direct modal shift to bicycle, either to bike sharing itself or indirectly to private bikes by normalizing cycling use; and to public transport, attracting new users by increasing its catchment areas and/or alleviating overcrowding. Second, to study causal relationships between the potential BSS advantages over car and its influence on inducing modal shifts. Consequently, this research should help at clarify the BSS ability in effectively reducing car use.

Author Keywords. Bike Sharing; Sustainable Mobility; Modal Shift

Topic: Hydraulics Technical Session III-A (27th.June)

AIR-WATER INFLUENCE IN THE PRESSURE SIGNAL DURING PIPE FILLING. #193

João Paulo Ferreira[1], Dídia Covas[2]

[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (joao.cavaleiro.ferreira@tecnico.ulisboa.pt)
[2]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt)

Abstract

This study presents a comparison between pipe fast filling with and without entrapped air. Experimental data are collected from a copper pipe coil with high-frequency pressure transducers to evaluate pressures during the filling phase until full pressurization. A steep pressure increased is observed near the storage tank that fills the systems and at the copper pipe mid-length. A progressive increase of the air pressure inside the copper pipe is observed until the moment that the flow reaches the pressure transducer. Pressure variations are collected due to air-water behaviour; these data will be further used to calibrate a numerical model.

Author Keywords: Pipe filling, experimental analysis, air-water behaviour.

OPERATIONAL MANAGEMENT OF HYDRAULIC INFRASTRUCTURES. APPLICATION OF A METHODOLOGY TO THE CASE STUDY OF THE WASTEWATER DRAINAGE SYSTEM OF TROFA. #168

Jorge Cardoso-Gonçalves[1], José Tentúgal-Valente[2]

1MSc in Civil Engineering / PhD Student, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jjtc.goncalves@gmail.com)
2PhD in Civil Engineering / Associate Professor, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (tentugal.valente@adp.pt)

Abstract

Water management is faced with uncertainties and risks at different levels, having to meet the needs of society through resilient solutions (economically viable, environmentally sustainable, socially responsible) and consider the current challenges, namely: safeguarding of water sources; security of supply; preservation of the receiving means; sustainable development; response to extreme phenomena; adaptation of systems to new demands; management in scarcity scenarios. In accordance with a commitment to continuous improvement and with a dynamic transversal to the entire organization of the Management Entities, Operational Management of Hydraulic Infrastructures should be focused on increasing efficiency standards for operational optimization and for the search for robust and effective solutions.

The development of the Operational Management of Hydraulic Infrastructures methodology, referred to in this communication, is framed in a doctoral thesis in development (Author: Jorge Cardoso-Gonçalves1; Advisor: José Tentúgal-Valente2) and intends to systematize procedures of the exploration of water supply systems and of drainage of waste water, and to support decision

making. The proposed methodology seeks to aggregate concepts of asset management, of risk management and of technical management, being organized into the following main components: Challenges; Organization; Operational Areas (Infrastructure Assessment, Exploration, Intervention).

Based on actual data of the exploitation of hydraulic infrastructures of the Trofa Wastewater Drainage System (SAR-Trofa), whose Management Entity is Águas do Norte, SA, the proposed methodology is tested and a Operational Management of Hydraulic Infrastructures strategy is designed for the reduction of operating costs, for the quality increasing of the provided service and for the safeguarding of environment. The study of the SAR-Trofa, from the point of view of infrastructure assessment, analysis and organization of exploration procedures, and systematization and proposal of interventions to be carried out, is performed with the objective to obtain practical results that support the operational management of these infrastructures, with particular focus on actions related to undue (rainfall and other) inflows.

Author Keywords. Operational management, wastewater, hydraulic infrastructures, undue inflows

ADDRESSING CHALLENGES AND UNCERTAINTIES IN ASSET VALUATION AND INFRASTRUCTURE INVESTMENT PLANNING. #174

Marta Cabral[1], Nuno Almeida[2], Jaime Gabriel Silva[3], Dália Loureiro[4], Dídia Covas[5]

1CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (marta.f.cabral@tecnico.ulisboa.pt) ORCID 0000-0002-2734-8504
2CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (nunomarquesalmeida@tecnico.ulisboa.pt) ORCID 0000-0001-7024-2679
3AdSA, Águas de Santo André, Cerca da Água Rua dos Cravos 7500-130 Vila Nova de Santo André, Portugal (g.silva@adp.pt)
4Urban Water Unit, National Civil Engineering Laboratory, Av. Do Brasil 101, 1700-066 Lisboa, Portugal (dloureiro@lnec.pt) ORCID 0000-0002-1169-7283
5CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt) ORCID 0000-0001-6901-4767

Abstract

The current paper aims to discuss the main challenges and uncertainties associated to asset valuation and infrastructure investment planning. The methodology adopted to address these issues is a three-step procedure: 1. Identification, characterization and site inspection of existing assets; 2. Estimation of the current replacement cost; and 3. Estimation of the current economic value. The application of this methodology presupposes dealing with numerous uncertainties, such as the calculation of the replacement cost, the choice of the degradation method and the selection and the correction of service lives according to assets' performance and physical condition. An industrial water supply system of the Industrial and Logistic Zone of Sines (ILZS) in Portugal is used as a real case study to highlight the complexity of asset valuation. Different competing investment alternatives were analyzed and assessed using a key performance indicator: the Infrastructure Value Index (IVI). Results include the IVI calculation for different assets using corrected service lives taking into consideration historical rehabilitation interventions and the estimation of future investment needs.

Author Keywords. Water supply system, asset valuation, investment planning.

MODELLING FLOW DYNAMICS IN DRINKING WATER STORAGE TANKS. #259

Alexandre Pinheiro[1], Laura Monteiro[2], Maria do Céu Almeida[3], Dídia Covas[4]

[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (alexandre.pinheiro@tecnico.ulisboa.pt) ORCID 0000-0001-8956-3018

[2]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (laura.monteiro@tecnico.ulisboa.pt) ORCID 0000-0001-5232-2018

[3]Núcleo de Engenharia Sanitária, Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal (mcalmeida@lnec.pt) ORCID 0000-0001-8488-2474

[4]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt) ORCID 0000-0001-6901-4767

Abstract

The research thesis in which this paper is included aims at understanding the effects of several governing factors on water mixing and on residence time distribution inside water storage tanks and identifying practicable solutions (infrastructural or operational) to improve the mixing performance and minimize the water aging. The research is being based on experimental tests carried out in laboratory small-scale tanks, specially assembled for this research. It includes velocity field measurement in laboratory experiments by using Particle Image Velocimetry (PIV). Advanced numerical modelling using Computational Fluid Dynamics (CFD) will be carried out to support the lab experiments.

Author Keywords. water storage tanks, flow dynamics, drinking water safety, numerical models, physical models

EFFICIENCY ASSESSMENT OF WATER SUPPLY SYSTEMS IN MATO-GROSSO, BRAZIL, THROUGH A BENCHMARKING ANALYSIS: IS THERE ANY REAL EFFICIENCY. #155

Marco Tourinho[1,2], Paulo Rosa-Santos[1,3], Francisco Taveira-Pinto[1,3]

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

[2]Secretaria de Desenvolvimento da Infraestrutura, Ministério da Economia, Bloco K, BRASÍLIA, Brasil

[3]ICIIMAR, Centro Interdisciplinar de Investigação Marinha e Ambiental da Universidade do Porto, Terminal de Cruzeiros de Leixões, Avenida General Norton de Matos, S/N, 4450-208, MATOSINHOS, Portugal

eng.tourinho@gmail.com (ORCID 0000-0002-5004-535X), pjrsantos@fe.up.pt (ORCID 0000-0002-3768-3314), fpinto@fe.up.pt (ORCID 0000-0003-4337-8428)

Abstract

Efficiency assessment (or benchmarking) have shown to be appropriate tools to simulate a competitive scenario in the water supply sector (Ananda, 2019;

Pawsey *et al*., 2018). In this sector, which has inherent monopolistic characteristics, the appropriate use of these tools stimulates the users' perception of systems and services and enables the construction of a balanced regulatory environment in which users have access to the operational information of the management entities that provides the water supply services.

However, a clear problem in the development of benchmarking is the definition of the management entity that will be considered as a reference for the others (the benchmark), namely in relation to the characteristics that define it as efficient. The use of information that has inherent inaccuracies is an obstacle to obtaining good results (Cabrera *et al.*, 2018). Moreover, the application of benchmarking methods, without taking into account the specifics of the systems (although with reliable data), and without realizing that there are many elements that influence them, can lead to inaccurate results.

A preliminary analysis of water supply services in municipalities of the state of Mato Grosso, Brazil, indicates that the application of the Data Envelopment Analysis (DEA) methodology, without observing the characteristics of the systems, can result in the definition of a service as efficient, even if the system has several major deficiencies that may not be perceived by the inputs or the outputs.

Author Keywords. Efficiency Assessment, Water Utility Performance, Benchmarking.

DEVELOPMENTS OF A NOVEL WAVE ENERGY CONVERTER BASED ON THE MOTIONS OF MULTIPURPOSE OFFSHORE FLOATING PLATFORMS. #159

Daniel Clemente[1], Paulo Rosa-Santos[2], Francisco Taveira-Pinto[3]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (ec10140@fe.up.pt) ORCID 0000-0003-4599-9287
[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (pjrsantos@fe.up.pt) ORCID 0000-0002-3768-3314
[3]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (fpinto@fe.up.pt) ORCID 0000-0003-4337-8428

Abstract

As the world faces complex challenges such as climate change, growing energy demand and energy security, strengthening the existing energetic mix is vital to ensure the sustainability of modern and future generations. As such, several renewable energy sources (RES) such as hydropower, wind and solar, have been developed over the last decades to tackle these challenges and present viable alternatives to fossil fuel solutions. Lately, their increasing level of maturity has allowed RES to become commercially competitive and attain a relevant share of the global energy market, which is expected to further increment in the near future. Even so, non-renewable sources remain the principal global suppliers, with all the nefarious consequences. Moreover, limitations and drawbacks inherent to the aforementioned RES exist and are non-negligible (Deng et al. 2015), allowing for other energy sources to have the opportunity of becoming relevant players in the global energy supply market.

Amongst the RES alternatives, marine renewable energy (MRE) has become one of the most promising sources, with an abundant theoretical resource and a higher power density than that of solar and wind, as well as greater consistency (Clément et al. 2002). MRE encompasses several variants, ranging from tidal to wave energy, each with different contributions to the overall theoretical resource. These have benefited from favorable supporting policies that have allowed for hundreds of different concepts to be studied and developed around the world. However, despite the high number of existing concepts, a definitive design consensus has yet to be reached, thus stopping the MRE sector from reaching a level of maturity alike its wind and solar counterparts. Moreover, the costs of developing, deploying and operating these devices remains high (Astariz et al. 2015) in comparison with other energy sources, making it difficult for MRE converters to reach a commercial stage.

One of the most pertinent obstacles to the successful development of a MRE converter regards its operational stage. After being deployed, a converter is subjected to the harsh marine environment, with key components becoming susceptible to fatigue, excessive loads and corrosion. This leads to high operation and maintenance costs (O&M) and additional logistical challenges to be addressed during the concept's life cycle. To counter this drawback, several concepts have recently been developed with a design that promotes the protection and isolation of key electromechanical components from the surrounding marine environment. Such is the case of wave energy converters (WEC) like the WITT (Crowley et al. 2018) and the ISWEC (Bracco et al. 2011), amongst others. Their design and operational mode is simple, yet versatile, allowing them to be, in theory, adaptable and attractive options for the wave energy sector.

Under this scope, a novel WEC concept has been developed over the last few years. Designated as the E-Motions, this device converts wave energy into electricity through wind and, mostly, wave induced oscillations of multipurpose floating platforms. This new concept can either be installed on existing platforms, such as vessels and ships, or incorporated into an optimized design aimed at incrementing the oscillatory response of the WEC. Analogous to the beforehand concepts, the E-Motions is capable of providing protection to the necessary equipment by sealing it within the hull of the floating platform. Furthermore, the operational principle is simple and the device can be adapted as to be integrated into various floating platforms for numerous applications.

Thus far, the E-Motions WEC has been subjected to an experimental proof-of-concept study (Clemente 2015) and a preliminary numerical assessment (Braga et al. 2018), with ANSYS® Aqwa™, from which initial results regarding its energy production and behavior were attained. Currently, the E-Motions is being subjected to a numerical optimization process supported by these results, which were used to calibrate the numerical model. Thus, presenting and discussing the latest stage of development of the E-Motions is the core purpose of this communication. In particular, the simulations carried out, thus far, encompass different geometries of the floating platform component, as well as various Power Take-Off (PTO) damping and mass value. The numerically reproduced model of this WEC was studied under different wave conditions. The results corroborate the complex and non-linear nature of the PTO-floating platform interaction and yield new estimates on the energy output of the E-Motions. Moreover, a preliminary study regarding the introduction of E-Motions units into potential deployment sites, carried out with the assistance of the SWAN/Delft3D third-generation software, is discussed under the

scope of the IACOBUS program, alongside the potential introduction of a control system is addressed through the application of the SimTwo numerical tool (Costa et al. 2011).

Author Keywords. Wave energy converter, Renewable marine energy, Optimization, Composite modelling.

SCOUR DEVELOPMENT UNDER DIFFERENT FLOW RATES FOR SEDIMENT MIXTURES. #249

Saeid Okhravi[1], Saeed Gohari[2], Rodrigo Maia[3]
[1]Ph.D. Candidate, Department of Water Engineering, College of Agriculture, Bu-Ali Sina University, Hamadan (65178-38695), Iran (s.okhravi94@basu.ac.ir)
[2]Assistant Professor, Department of Water Engineering, College of Agriculture, Bu-Ali Sina University, Hamadan (65178-38695), Iran (s.gohari@basu.ac.ir)
[3]Associate Professor, Departamento de Engenharia Civil, Faculdadede Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, s/n, Porto 4200-465, Portugal (rmaia@fe.up.pt)

Abstract

Bridge piers are often located in channel riverbeds formed by non-uniform sediment mixtures. However, the influence of bed sediment types on the scour process are not yet well understood. Therefore, a series of laboratory experiments were conducted in a channel for five different sediment beds under two steady flow discharges (20 and 35 l/s) around a single bridge pier model. Two of the sediment beds were composed of uniform sand and in the remaining three, the sediment was non-uniform. The results showed that in general the scour depth increases with the flow discharge increase. However, the rate of variation of erosion depth over time is very different for the various bed sediment types. For the same median sediment size and flow condition, the scour depth was found to decrease dramatically as the non-uniformity index increased, due to the development of an armor layer. Following the results, the impact of the median grain size of complex mixtures of sediment is also discussed.

Author Keywords. Armor layer, Flow conditions, Local scour depth, Non-uniform sediments

Topic: Spatial Planning Technical Session III-B (27th.June)

EMPIRICAL ASSESSMENT OF THE CO-DEVELOPMENT OF RAIL AND LAND INTOKYO. #75

Marcelo Altieri and Álvaro Costa

Abstract

It is well-acknowledged the mutual relationship between transportation infrastructure and urban development. Transportation infrastructure stimulates urban development through providing better accessibilities, which then grant premium to estates within its reach, as well as fast-growing urban areas stimulates transportation development through increasing the demand for transportation and supporting further expansion.

The number of studies that succeeded to evidence that some cities, regions or neighbourhoods intentionally developed transport infrastructure prior to urban land through a historic approach outweighs the few other that had empirically assessed the order between both. Briefly, empirical studies use quantitative data and complex regression analysis techniques to asserts the classic 'chicken and the egg' question and thus establish an order between transport and urban development: Does urban development lead to the construction of new transport infrastructure to support it, or do new services on vacant-land induce new urban development?

Empirical studies have assessed the co-development of land and rail in New York and London. Both studies found a negative contemporaneous relationship between land use and rail development in the core whereas just London have found a positive contemporaneous relationship in the periphery. Nonetheless, the results found no lagged relationships between rail and land development in the periphery. The negative feedback in the core relates to the competing relationship between residential and commercial uses, a common pattern across most metropolis. On the other hand, the absence of a positive feedback in New York, especially in its periphery, is often related to the lack of interest of public transport companies on developing empty areas. The positive feedback in London may result from real estate ventures developed by some railway companies along services in the outskirts, like the Metropolitan Railway and its Metro Land. Differently from western cities, most major and some minor private railways companies in Tokyo strategically developed real estate and other non-transport-related business to generate ridership in a very competitive market, notably in its periphery. This research proposes to empirically assess the existence of lagged relationships between land and rail development in Tokyo, a city where the co-development of rail and land is well documented.

The panel is structured in a 5-year interval according to the Japanese census, which ranges from 1920 with the last available record for the year 2010, providing a total of 19 regular intervals. Exception regards the year 1945, which due to the War was based on a survey and the proper census was delayed to the year 1947. Further spatial and time stratification were conducted to avoid the War break biasing and to capture differences between the core, the inner ring, and the periphery.

Several lag periods were tested, as well as combinations of one-period and two-period lags across unrestricted and restricted time-series stratification. Different lag-structures was found: 5-year interval in the core, 20 to 25-year interval in the inner ring, and 30 to 35-year interval in the periphery. The results find that surface rail network lagged population development in the inner ring and in the peripheral by 20 to 35-year, respectively. Contemporaneous effects were found: negative between population and underground rail in the core; and positive between population and surface rail in the periphery.

Author Keywords. Transport, Land use, Tokyo, network growth, population growth

IDENTIFICATION AND ANALYSIS OF RISK FACTORS RELATED TO ROAD INFRASTRUCTURE TO SET COUNTERMEASURES. #91

Mariane Paula Bobermin[1], Sara Ferreira[2]

[1]Faculdade de Engenharia, Universidade do Porto, Portugal (mariane.bobermin@fe.up.pt)
[2]Faculdade de Engenharia, Universidade do Porto, Portugal (sara@fe.up.pt) ORCID 0000-0001-7469-3186

Abstract

Despite the Decade of Action for Road Safety is coming to an end, and some improvements have been made in this period, the Sustainable Development Goals target 3.6 to halve road traffic deaths by 2020 will not be achieved, and efforts on road safety will continue to be a pillar to guide global actions into accident prevention for the next decade (World Health Organization 2018). One strategy that can be adopted towards road safety is the System Approach (Reason 1990) which considers that humans are fallible, and errors are expected to occur. Therefore, the objective is to understand the influence of different factors that contribute to the system fail (i.e. the accident).

Indeed, transport systems are heterogeneous, depending on driver population, road characteristics, weather conditions, traffic conditions, and road design standards. Hence, identification of the relationship between traffic accidents and the causative factors is a complex task, but it is the first step in the adoption of preventive measures to reduce the number and severity of traffic accidents.

One of those factors is the road infrastructure that drivers are exposed to. According to Papadimitriou et al. (2019), fifty-nine road risk factors associated to road infrastructure were identified under a review process to be potentially related to accident severity and frequency. Some of them were considered high risk level, whilst many of them demonstrated negative impact, but more studies are still required to determine the extension of their influence.

In this context, this study aims to identify the main characteristics of the road infrastructure of single lane highways associated to traffic accidents in the Brazilian federal road network. Firstly, data from accidents (police reports) will be assigned to road infrastructure, creating a dataset with both characteristics. Secondly, an exploratory analysis of this dataset will be conducted using a clustering method in order to identify groups in which specific road infrastructure characteristics are associated to accident severity and/or frequency. Former researches on traffic accidents (Depaire, Wets, and Vanhoof 2008) advise the application of a

classification technique before a further analysis of each group and its specific characteristics.

The exploratory analysis will guide the selection of the road infrastructure characteristics to be investigated mainly in terms of driver behaviour influence, in order to understand the situations that eventually lead to accidents. Finally, and based on the mentioned selection, scenarios will be set and implemented in a virtual environment to perform a driving simulator experiment to directly access driver interaction with road infrastructure characteristics and with countermeasures designed to improve road safety.

Author Keywords. traffic accidents, road safety, road infrastructure, clustering analysis, driving simulator.

UNCOVERING TRENDS AND DETERMINANTS OF COMMUTING PATTERNS IN ACADEMIA. #60

Catarina Cadima[a], Cecília Silva[b], Paulo Pinho[c]

CITTA - Research Centre for Territory, Transports and Environment
Faculty of Engineering of the University of Porto (Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal)
a catarina.cadima@fe.up.pt, ORCID 0000-0002-4969-5013
b ccsilva@fe.up.pt, ORCID 0000-0003-2868-1840
c pcpinho@fe.up.pt, ORCID 0000-0001-5159-8856

Abstract

Commuting patterns generate environmental impacts which study has been attracting the interest of scientists and authorities on the search for environment-friendly alternatives. While general awareness of sustainability issues has improved through mass media coverage, the corresponding knowledge is not always translated into actual sustainable practice in universities. University students are considered a dynamic group. having a significant impact on local housing markets. Yet, students are temporary residents with little power and often invisible to policy design. Nevertheless, their daily commuting to campus may generate adverse impacts, like traffic congestion and parking pressure on surrounding areas and on the performance of the local transport system.

Our purpose is to explore how commuting patterns of university students have changed over the last decade identifying if they are becoming more sustainable. In order to obtain a deeper understanding of travel behaviour of university students we combine (i) local spatial factors with (ii) personal factors in three different moments: 2006, 2012 and 2017. We used Geographic Information Systems (GIS) to collect data information on residential location and accessibility from each student (macro social information from Portuguese Census and document analysis - transport system) and we cross this information with data from personal surveys. In total, we collected 345, 352 and 430 responses in 2006, 2012 and 2017, respectively from a representative sample of the student population from the Faculty of Engineering of the University of Porto (FEUP). Multinomial logistic models were performed to accomplish our objectives. We used non-motorized-transport (NMT), public transport (PT), and the private car (PC) as outcomes.

The findings reveal that FEUP students' commuting patterns have changed significantly. When we crossed data over time our results showed that (a) travel attitudes are gradually changing pointing to more sustainable behaviours (b) and students are increasing their accessibility conditions. Notwithstanding, our results

also revealed the spatial analysis zones were most students still use the private car. Understanding the key factors underlying students' modal choices is crucial to assist university leaders in the development of their community engagement strategy to motivate their community members to take practical steps towards building a sustainable campus.

Author Keywords. Travel behaviour; modal choice; sustainable mobility; university students Oporto Metropolitan Area.

THE ROLE OF URBAN DESIGN IN BREAKING CAR-ORIENTED MINDSETS. #106

Ana Cláudia Proença[1], Cecília Silva[2], José Palma-Oliveira[3]

[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (anaclaudia@fe.up.pt) ORCID 0000-0002-0180-273X
[2]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ccsilva@fe.up.pt) ORCID 0000-0003-2868-1840
[3] Faculdade de Psicologia, Universidade de Lisboa, Cidade Universitária, Alameda da Universidade, 1649-004 LISBOA, Portugal, (jpalma-oliveira@psicologia.ulisboa.pt) ORCID 0000-0001-9799-3464

Abstract

After the World Wars, cities around the world have increasingly been planned and developed to accommodate road traffic and related mobility patterns by fomenting the required urban infrastructure, contributing to issues like traffic congestion, air and noise pollution and resulting climate change and health problems to rise. These concerns sparked renewed interest to explore the link between mobility and urban form, considering that car-oriented cities seem to be caught in a vicious cycle of car use by the population and urban and transport planning by planners directed at the car, resulting in private car dependency and a generalized car-oriented mindset.

This paper follows the objective of defining the effects of urban planning and, by consequence, urban design on the population's behaviour and mindset towards mobility, further exploring the car-oriented mindset that is prevalent in nowadays societies, where most streets are less friendly to pedestrians than they are to cars, leading to a reduced accessibility by sustainable modes. By understanding the effects not only on the mobility behaviour, but also on the attitudes, opinions, values and beliefs that guide that behaviour, the psychosocial repercussions of short and long term urban interventions can be better understood and the municipality's mobility strategy can be better tailored, contributing to urban planning enrichment towards sustainable cities by defining the urban traits that inspire better mobility mindsets.

In order to achieve this goal, case-studies in neighbourhoods with particular characteristics will be selected and evaluated by gathering quantitative data with surveys and qualitative data after street intervention with interviews. The data collected between communities of different types of urban designs and in the same population before and after intervention will shed light on the interaction between built environment and human mindset towards mobility.

Author Keywords. Urban Design, Mobility Mindset, Mobility Behaviour, Place Attachment.

Topic: Structures Technical Session IV-A (28th.June)

SEISMIC VULNERABILITY ASSESSMENT AND RETROFITTING STRATEGIES FOR INFILLED RC FRAME BUILDINGS. #96

André Furtado[1], Hugo Rodrigues[2], António Arêde3, Humberto Varum[4]

1CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Portugal (afurtado@fe.up.pt)
2RISCO, Escola Superior de Gestão e Tecnologia, Instituto Politécnico de Leiria, Portugal (hugo.f.rodrigues@ipleiria.pt)
3CONSTRUCT-LESE, Faculdade de Engenharia da Universidade do Porto, Portugal, (aarede@fe.up.pt)
4CONSTRUCT-LESE, Faculdade de Engenharia da Universidade do Porto, Portugal, (hvarum@fe.up.pt)

Abstract

The out-of-plane (OOP) performance of infill masonry walls subjected to earthquakes is a topic of growing importance due to the significant number of collapses observed through the recent earthquakes. Nowadays is recognized by the scientific community the influence of these elements in the structural response of reinforced concrete structures subjected to seismic actions. The infills OOP behaviour depends on a series of variables and there is a lack of experimental data to understand and predict their expected seismic performance. There is a need of data to calibrate numerical models and to understand the effect of each variable such as type of masonry, boarder constrains, previous in-plane damage and insufficient support width in the infills OOP capacity. The present manuscript pretends to overview some considerations regarding the performance assessment of the infill panels OOP behaviour based on experimental tests.

Author Keywords. Masonry infill walls, out-of-plane, seismic behaviour, experimental testing, strengthening technique.

SEISMIC ASSESSMENT OF AN INDUSTRIAL PRECAST RC BUILDINGS. #252

Nádia Batalha[1], Hugo Rodrigues[2] and Humberto Varum[3],

1CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Portugal (afurtado@fe.up.pt)
2RISCO, Escola Superior de Gestão e Tecnologia, Instituto Politécnico de Leiria, Portugal (hugo.f.rodrigues@ipleiria.pt)
3CONSTRUCT-LESE, Faculdade de Engenharia da Universidade do Porto, Portugal, (hvarum@fe.up.pt)

Abstract

Precast concrete buildings are a common building typology in the Portuguese industrial park and looking to its performance in recent earthquakes around Europe it can be observed a poor performance both at structural and non-structural levels. Their characterization becomes important in order to know better its seismic behavior to mitigate the seismic risk. The one-story industrial buildings, with a frame structure of beams and columns, with a fixed connection at the base and hinged at the top, on which variable section beams are later supported is the most recurrent solution in Portugal. In this sense, this work deals with the seismic behavior of a frame of an existing industrial building, with prefabricated concrete structure. This characterization is performed through non-linear static and dynamic analysis.

Author Keywords. Industrial buildings, Precast RC buildings, Seismic performance, Pushover analyses, Dynamic analysis.

INFLUENCE OF SEISMIC ACTION ON BRAZILIAN REINFORCED CONCRETE BUILDINGS: PARTIAL RESULTS. #156

Paulo Miranda[1], Humberto Varum[2], Nelson Vila Pouca[3]

[1] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (paulo.miranda@fe.up.pt)
[2] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (hvarum@fe.up.pt)
[3] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nelsonvp@fe.up.pt)

Abstract

Brazil is in the central region of the South American plate, being therefore a low-to-moderate seismicity country. Many earthquakes in Brazil are associated with global character tectonic movements. The tectonic forces act in fragile zones called zones of discontinuity giving rise to the earthquakes. The Brazilian seismic records, although very recent, generally point to maximum 5.5 magnitude earthquakes and by now, these events did not bring great consequences. However, some events in the recent past were reason for concern. The magnitude 5.2 earthquake occurred in 1980 in the city of Pacajus-CE and the magnitude 5.1 earthquake occurred in 1986 in the city of João Câmara-RN caused partial or total buildings collapses, many buildings had to be rebuilt or recovered and people were injured and made homeless. Depending on the depth of the focus, the soil type, the characteristics of the buildings and the exposure of people, earthquakes of this magnitude can, in fact, lead to great tragedies. Elsewhere in the world, earthquakes of magnitude like those already recorded in Brazil caused much destruction. Another aspect to consider is that even in intraplate regions, strong earthquakes have been observed causing great losses. In these regions, the strong earthquakes probability of occurrence is much lower than in the plate's boundary regions. However, the stable nature of the soils of the central plate regions leads to more efficient propagation of seismic waves, characterizing them as potential areas for catastrophic earthquakes. The damage observed in the intraplate regions can be intense, not only due to the geological characteristics, but also due to the lack of anti-seismic care in buildings and the lack of population capacity to react to the situation. In 2006, considering the seismic activity increase in Brazil in the recent years and the need to adapt Brazilian technical codes to international requirements aiming economic integration with other countries in the world, the Brazilian Association of Technical Codes published the NBR 15421 – Design of seismic resistant structures. This code deals with the obligation to consider seismic actions in new structures designs and presents a map based on World Seismic Hazard Program that divides Brazil into five seismic zones. Most of the Brazilian territory is in seismic zone 0, region where no seismic resistance requirement is necessary. Answers of a form applied to Brazilian structural engineers indicate a low knowledge level of the seismic code and the rare usage of its recommendations in structural designs. From the seismic point of view, the comfortable situation of the Brazilian scenario exposes the fragility of the structures, since, different from the vertical loads that are easily and constantly verified from the moment the structure is put to the test, the verification of horizontal loads, like seismic action, is only possible through numerical or experimental simulations, or during the actual loads application in the structures. In Brazil, in terms of research, there are few published works in the area. In these works, the structural models adopted do not represent a Brazilian city building inventory; in

addition, the topographic and geological parameters assumed do not represent real situations or follow national mapping criteria. In this present work, a residential inventory building survey of the city of Fortaleza, capital of Ceará, was carried. Ceará is one of the most seismically active states in Brazil. Aspects such as number of buildings, number of storeys, age of buildings, design codes considered, and materials used were evaluated. Concrete structures are the more used system for residential buildings in Fortaleza and the city has shown a marked increase in high buildings in the last 40 years. Some buildings, especially the small and low ones are generally built without specific structural designs and made of inadequate materials. The buildings also have certain architectural and structural characteristics that raise questions about adequate behavior under seismic actions. Structural models were created from the inventory data collected and they will be submitted to the seismic action's influence evaluation. These processes aim to verify the vulnerability level of Fortaleza existing buildings and depending on the results to raise awareness and disseminate actions for seismic risk reduction. The comparative study of NBR 15421: 2006 with seismic codes from other countries also permitted to identify the very broad aspect of Brazilian zoning map, not addressing the specific characteristics of Brazilian seismicity. Even in low-to-moderate seismicity countries, detailed seismic risk and zoning studies are justified by the high seismic risk, often caused by the high vulnerability of buildings and the large exposure of people. The Brazilian seismic records evaluation, especially since the 1980s, indicates a different configuration of the seismic hazard in Brazil. This work presents Brazilian seismicity aspects, indication of seismic vulnerability of Fortaleza's buildings and the methodology to be applied to verify the influence of seismic actions on its reinforced concrete structures.

Author Keywords. Intraplate region, Seismic vulnerability, Concrete structure.

ON THE APPLICABILITY OF CONVENTIONAL SEISMIC DESIGN METHODOLOGIES TO HYBRID RC-STEEL SYSTEMS. #201

Rodrigo Falcão Moreira[1], José Miguel Castro[2], Humberto Varum[3]

1 CONSTRUCT-LESE, Faculty of Engineering, University of Porto (rodrigo.moreira@fe.up.pt)
2 CONSTRUCT-LESE, Faculty of Engineering, University of Porto (miguel.castro@fe.up.pt)
3 CONSTRUCT-LESE, Faculty of Engineering, University of Porto (hvarum@fe.up.pt)

Abstract

This study analyses the adequacy of the q-factor approach (a linear static design method with reduced input seismic action) when applied to older-type RC structures retrofitted with concentric steel braces. This approach is prescribed by EC8-1 (2004) as the basic design method and usually referred to as the most conservative. However, due to its simplicity and popularity for the design of new structures, practitioners are more likely to resort to it than to more complex nonlinear static and dynamic procedures when involved in situations requiring the seismic assessment and strengthening of existing RC buildings. The study starts by reviewing the q-factor approach defined in EC8-3 (2005) for the seismic assessment of existing structures and then proceeds to analyse the difficulties a practitioner will face when defining and evaluating the efficiency of a steel-brace retrofitting system within the framework of EC8-1 (2004). Afterwards, the validation of the design

methodology is discussed, using nonlinear dynamic analysis to evaluate the performance of the obtained retrofitted structures according to EC8-3 (2005). Finally, an application example is presented and conclusions about the adequacy of the tested force-based methodology are drawn from the obtained results.

Author Keywords. Seismic assessment and retrofitting of existing RC structures, Concentric steel braces, Hybrid RC-steel systems, Behaviour factors, Force-based seismic design, Displacement-based seismic design.

ANALYTICAL STUDY FOR FORMS AND DIMENSIONS OF MINARETS IN ALGERIA. #8

Beldjilali Said[1], Bougara Abdelkader[2], Varum Humberto[3],

1University of Abdelhamid Iben Badis de Mostaganem, Algérie 2 Université of Hassiba Benbouali de Chlef, Algérie- 3 University (FEUP) Porto, Portugal

Abstract

The Islamic heritage constitutes a very precious treasure in Algeria; it provides the image of these cities as KSOUR (castles) and individual houses types Haouche but especially the places of worship (mosques) which express the symbol of this architecture. They are considered as important landmarks of Algerian cities through these architectural elements such as the dome and the minaret. There is a lot of research on the behaviour of religious elements such as temples in the Nepalese pagoda or cathedrals. First, these minarets are used by the muezzin to invite people to prayer; they were previously built near the mosque or inside it next to the prayer room, later they appeared as angle towers. of mausoleums. During 1400 years of Islamic civilization, a numerous forms of minarets are developed. The minarets in Algeria of the medieval period (Bani Hamad, Eelmorafid, Zianides, Mérinides and Ottomane) were selected, and then classified according to several typologies, (dimensions, forms, design ...). This research is part of an analytical study of minarets in Algeria and its evolution over time. The main objectives of this work can be summarized in the search for the forms that determine the typology of minarets and to draw a canevas for the features and architectural elements, varying and invariant of minarets of each period. Look for an identity and an original architectural reference of each period is also targeted in this investigation. The methodology followed in this analysis is that of the monographic method which relies on observation and field work while introducing a thorough reading of history. The results found from this analysis showed that the rectangular shape of the main tower of the minaret represents 2/3 with the same dimensions between the top and bottom, whereas the square shape of the section of the main tower of minarets represents ½ which symbolizes the most earthquake resistant form.

Author Keywords. Minarets, ornaments, originality, report, heritage.

ADVANCED METHODOLOGY FOR MONETARY LOSS ESTIMATION OF REINFORCED CONCRETE FRAMES. #338

Tuba Tatar[1], Mario Marques[2], Mario Pimentel[3], Jose Miguel Castro[3]

[1]PhD Student at University of Porto
[2]Investigator at University of Porto
[3]Assistant Professor at University of Porto

Abstract

While seismic risk assessment is the first step of understanding the impact of earthquakes and the need of seismic rehabilitation, it is important for both pre-earthquake preparedness and awareness to provide an accurate estimation of the human and economic losses that are likely to occur in a certain region. The aim of this paper is to present a new methodology for analytical and trustworthy seismic risk assessment of reinforced concrete moment resisting frame buildings. This procedure is deemed crucial for regions in where although their moderate to high seismicity (i.e. Portugal) there is a lack of robust post-earthquake data to derive empirical relationships between damage and cost to repair and thus, to develop appropriate risk management decisions from cost-benefit analyses.

Author Keywords. Seismic risk assessment, damage, loss ratio, axial load.

Topic: Building Construction Technical Session IV-B (28th.June)

ENHANCEMENT OF CONSTRUCTION ON-SITE QUALITY CONTROL BASED ON NEW IT. #11

Rui Bessa[1]

1 Construct-GEQUALTEC, Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ruibessa07@gmail.com) ORCID 0000-0001-7008-7533

Abstract

Construction Quality Control on-site reacts to facts and lacks a systematic and based on real-time data approach. The shortcomings of this control directly affect the quality of the product, having an impact on direct and indirect costs. Moreover, it allows systematic errors to occur in construction projects, making it difficult to determine its causes and origins, thus preventing their mitigation through preventive actions. The presented work aims to develop a framework for on-site compliance checking that integrates "As-built" information in the quality records. The goal of the developed framework is to classify on-site control information to enable timely actions based on real-time data in order not only to prevent and mitigate defects occurrence but also to evaluate quality control performance. The developed framework was tested on the construction site, in a case study context. The presented work shows greater assertiveness of compliance checking at lower costs and provides complete records with organized information.

Author Keywords. Quality Control, On-site Compliance Checking, Construction Information Systems, Quality Management.

AIR PERMEABILITY OF BUILDINGS WITH MODULAR LIGHT CONSTRUCTION SYSTEMS IN SOUTHERN EUROPE: GAPS AND NEEDS. #151

Vitor E.M. Cardoso[1], Nuno M.M. Ramos[1], Ricardo M.S.F. Almeida[1,2] and Manuela Almeida[3]

1 University of Porto, Faculty of Engineering, LFC - Laboratory of Building Physics, Porto, Portugal (v.cardoso@fe.up.pt) ORCID 0000-0002-4886-2406 (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429
2 Polytechnic Institute of Viseu, School of Technology & Management, Civil Engineering Department, Viseu, Portugal (ralmeida@estv.ipv.pt) ORCID 0000-0002-9846-6081
3 University of Minho, Civil Engineering Dep., Centre for Territory, Environment and Construction, Guimarães, Portugal (malmeida@civil.uminho.pt) ORCID 0000-0003-2713-6322

Abstract

Modular light construction systems are a recent trend in mild climate countries of southern Europe. Still, several gaps on their design must be filled for them to be a viable option in the future. A fitting air permeability approach is one of these challenges. In this short paper several topics on the issue will be presented and gaps and needs will be discussed. Conclusions on how to achieve high performance air permeability in the context of southern Europe will be made.

Author Keywords. Air permeability, Airtightness, Modular light construction, Energy efficiency, Ventilation, Building simulation.

AN INITIAL APPROACH TO AUTOMATIC BUILDING INFORMATION MODELLING. #158

Luís Sanhudo[1], João Poças Martins[2], Nuno M. M. Ramos[3]

[1] CONSTRUCT-GEQUALTEC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (lpnsanhudo@fe.up.pt) ORCID 0000-0002-2578-6981
[2] CONSTRUCT-GEQUALTEC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jppm@fe.up.pt) ORCID 0000-0001-9878-3792
[3] CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429

Abstract

In the last few years, although there has been an increasing need to accurately acquire structured and semantically enriched 3D digital models of existing buildings in the Architecture, Engineering and Construction (AEC) industry, currently, no software has ensured the direct shift from point clouds to complete enriched BIM models. In fact, despite recent efforts from software to import point clouds into their modelling environment, the subsequent modelling process still remains largely manual, time consuming, labour-intensive, subjective, and error-prone.

To help solve this issue, the authors propose a twostep framework where building elements are initially segmented and identified in point clouds using machine learning techniques, followed by their automatic modelling within appropriate Building Information Modelling (BIM) authoring software. This oral communication will focus on an initial approach to the second step of this framework.

Author Keywords. BIM, software, building elements, automatic modelling.

BALCONY SPACES: THE IMPACTS ON INDOOR ENVIRONMENT AND ENERGY EFFICIENCY. #175

Catarina F. T. Ribeiro[1], Nuno M. M. Ramos[2], Inês Flores-Colen[3]

1 CONSTRUCT-LFC, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (catarina.cato@gmail.com) ORCID 0000-0001-8671-0457
2 CONSTRUCT-LFC, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429
3 CERIS, DECivil, Instituto Superior Técnico (IST), Universidade de Lisboa, Av. Rovisco Pais, Lisboa, 1049-001, Portugal (ines.flores.colen@tecnico.ulisboa.pt) ORCID 0000-0003-4038-6748

Abstract

The balcony is a space in-between that has the ability to mediate the outdoor and the indoor environment. This communication provides a holistic review of the impacts of balcony morphology on the indoor environmental conditions and the energy performance on dwellings.

Author Keywords. Balcony space, Comfort, Indoor environment quality, Energy efficiency.

COMFORT EVALUATION OF DWELLINGS LOCATED IN HISTORICAL BUILDINGS IN SOUTHERN EUROPE. #208

Sílvia A. Magalhães[1], Vasco Peixoto de Freitas[1]

1Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (silvia.magalhaes@fe.up.pt; vpfreita@fe.up.pt)

Abstract

The thermal performance evaluation of buildings relies on the European Directives on Energy Performance of Buildings, providing the framework on which all member states should improve their buildings 'energy efficiency'. However, it is established in several literature, there is an important gap between normative calculations and measured consumptions. In Portugal, this is explained by a mild climate and a high fuel poverty phenomena. Thus, for low heating countries, the thermal performance should rely on the discomfort minimization. It was performed the comfort assessment of dwellings located in the typical building with massive walls and wooden pavements and roof, with or without insulation on walls, for different orientations. The numerical model was validated with experimental data. The comfort was assessed considering the adaptive approach of the European Norm 15 251, for free running conditions, or with low heating profiles. Results show the insulation introduction has a very small impact on discomfort minimization, for low heating profiles in mild climates, what shall be considered, bearing in mind it presents many times technical difficulties in historical buildings.

Author Keywords. Comfort evaluation; Adaptive comfort; Southern Europe, Low heating, Energy Certification

A CLASSROOM PROTOTYPE REFURBISHMENT – HEATING STRATEGIES. #248

Francisca Cavaleiro Barbosa[1], Vasco Peixoto de Freitas[1], Manuela Almeida[2]

1Construct-LFC, Department of Civil Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (francisca.barbosa@fe.up.pt, vpfreita@fe.up.pt)
2CTAC, Department of Civil Engineering, School of Engineering, University of Minho, Campus de Azurém . 4804 - 533 Guimarães, Portugal, (malmeida@civil.uminho.pt)

Abstract

Portuguese school buildings are generally characterized by an in service thermal discomfort, due to the poor envelope thermal properties and the lack of resources for paying energy consumption. This work studies the Portuguese *Brandão* schools model. A prototype classroom was prepared in a *Brandão* school, in Porto. Some studies were carried out regarding the thermal behavior before and after the prototype refurbishment, by experimental monitoring. The prototype construction has included the improvement of the envelope and of the technical systems. This work presents the prototype thermal performance after the refurbishment in free-running conditions and with some intermittent heating strategies. Discomfort indexes have been developed for the assessment of the discomfort.

Author Keywords. School buildings, prototype, experimental monitoring, heating strategies, thermal comfort.

GREEN ROOFS – AN EXPERIMENTAL SETUP TO MEASURE THE HYGROTHERMAL PERFORMANCE AND COMFORT CONDITIONS. #261

Sara S. de Freitas[1], Nuno M.M. Ramos[2], Hartwig M. Künzel[3], Daniel Zirkelbach[4]

[1]LFC – CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (sarafreitas@fe.up.pt)
[2]LFC – CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt)
[3]Fraunhofer Institute for Building Physics IBP, Holzkirchen Branch Fraunhoferstr. 10, 83626 VALLEY, Germany (hartwig.kuenzel@ibp.fraunhofer.de)
[4]Fraunhofer Institute for Building Physics IBP, Holzkirchen Branch Fraunhoferstr. 10, 83626 VALLEY, Germany (daniel.zirkelbach@ibp.fraunhofer.de)

Abstract

Green roofs are a spreading technology due to many benefits being reported at several levels: city, building, component and users. The advantages include improvement of the urban environment, enhancement of comfort conditions, and reduction of energy consumption. Consequently, the measurement of the real hygrothermal behaviour of green roofs is a key aspect for the design and validation of solutions.

This work focuses on the results of an experimental setup campaign for a green roof test building located in Porto which is characterized by a Mediterranean/Atlantic climate. The monitored data include temperature profiles, water content profiles, near surface heat fluxes, roof surface temperature and air temperature profiles above the roof surface. The experimental results obtained show a strong influence on the surface temperature and exterior heat fluxes during summer compared to the performance of the conventional roof. However, the impact on air temperature and relative humidity proved to be of minor significance.

Author Keywords. green roofs, hygrothermal performance, comfort, experimental measurements

NON-PROPRIETARY UHPFRC FOR USE IN REHABILITATION/STRENGTHENING APPLICATIONS. #143

Ana Mafalda Matos[1], Sandra Nunes[2], José L. Barroso-Aguiar[3]

1 Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (up200505574@fe.up.pt)
2Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (snunes@fe.up.pt) ORCID 0000-0002-4876-2587
3 Escola de Engenharia da Universidade do Minho (aguiar@civil.uminho.pt) ORCID 0000-0003-3954-5721

Abstract

Ultra-High Performance Fibre Reinforced Composites (UHPFRC) are produced with a high content of binder, low water-to-binder ratio, short high-strength steel fibres, and absence of coarse aggregates. The mix-design of UHPFRC involves a reduction in porosity, improvement in microstructure and homogeneity of the matrix phase, which combined with a sufficient amount of steel fibres provides distinctly high compressive strength (>150MPa), improved tensile behaviour (10-20MPa tensile strength with 3-10‰ strain-hardening), and excellent durability. Due to these superior properties, UHPFRC has great potential for the next generation of infrastructures - more resilient and sustainable -, but more efforts are needed to turn it into a widespread 'regular' technology (Azmee and Shafiq 2018).

Within the current PhD, for the first time, the spent equilibrium catalyst (ECat) - generated in the oil refineries – was studied as an internal curing agent to reduce UHPFRC autogenous shrinkage without impairing mechanical properties and durability (Matos et al., n.d.). The typically very high autogenous shrinkage of UHPFRC is a major concern to ensure long service life due to the early age cracking risk, namely, when the deformations are restrained as is the case in rehabilitation/strengthening applications.

Results showed that the incorporation of ECat, and the corresponding extra water that the ECat can absorb, lead to a significant reduction of the autogenous shrinkage of UHPFRC; exhibiting similar performance to the commercial products often used for internal curing, such as superabsorbent polymers and very fine lightweight aggregates. The use of ECat in UHPFRC also has the potential of enhancing the hydration due to more availability of water in the system and to its high pozzolanic activity (Nunes and Costa 2017). This allowed achieving a new UHPFRC mixture with comparable performance but lower cement content, with advantages regarding the cost and the CO2 emissions. Moreover, the replacement of the natural sand with a residue allows both limiting the excessive exploitation of natural resources and a waste recycling that is diverted away from landfills.

Author Keywords. UHPFRC, spent equilibrium catalyst, Autogenous shrinkage, Durability, Sustainability.

ECOLOGICAL, PHOTOCATALYTIC, SUPERHYDROPHOBIC AND SELF-CLEANING ASPHALT PAVEMENT SURFACES. #17

Iran Rocha Segundo[1], Salmon Landi Jr.[2], Elisabete Freitas[3], Joaquim Carneiro[4]

1 Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal (iran_gomes@hotmail.com),
2Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal and Federal Institute Goiano, Rio Verde – _GO, Brazil (salmon.landi@ifgoiano.edu.br),
3Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal (efreitas@civil.uminho.pt),
4Physics Department, University of Minho, Azurém Campus, Guimarães, Portugal (carneiro@fisica.uminho.pt).

Abstract

The aim of this research is to develop multifunctions on recycled asphalt mixtures for the surface layer of road pavements. Therefore, preliminary research on functionalization has been carried out. Afterwards, the asphalt mixtures were designed and characterized by mechanical and superficial point of views. The next step is the design of the nanomaterials, their application on asphalt mixtures and the characterization from physical, mechanical and superficial behavior.

Author Keywords. Photocatalysis, Superhydrophobic, Self-Cleaning, Surface Characteristics, Recycled Asphalts Mixture

STUDY OF POLYETHYLENE TEREPHTHALATE (PET) PLASTIC BOTTLES IN THREADED FORM AS MICRO LEVEL REINFORCEMENT IN FLY ASH CONCRETE. #221

Manpreet Singh and Satgur Singh,

Department of Civil Engineering, Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA) dullat.mani@gmail.com

Abstract

The growing environmental concerns and proper disposal of construction and demolition waste is a challenge for construction industry. Now a day in our country Solid waste management is one of the major environmental concerns. A substantial growth in the consumption of plastic is observed all over the world in recent years. The use of demolition waste as a resource for recycling or recovery is gaining grounds in many countries. The proper selection and processing of demolition waste can be helpful in producing concrete. In construction industries, concrete masonry units are used commonly. The use of plastic bottles in construction materials has been around for the past twenty years, but with little focus on using threaded plastic bottles in the materials. This work aimed to justify use of threaded plastic bottles and fly ash in concrete. It also aims to investigate the strength of concrete when plastic bottles are used. Plastic bottles are increasingly becoming a menace to the environment due to the chemicals used in the manufacture, improper use and disposal. Waste plastic bottles are major cause of solid waste disposal. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse. As noted by Plastics Industry (2017) reusing plastic bottles may seem safe, but a chemical found in reusable plastic bottles, known as bisphenol A. (BPA) is suspected of

posing a health risk to human beings. Hence, the safest way of disposing plastic bottles is to recycle them, particularly they can be used in the construction. The use of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. Plastic bottles are difficult to reuse, recycle and non-biodegradable and hence creates an environmental issue. A healthy and sustainable reuse of plastics offers a host of advantages. The suitability of recycled plastics as coarse aggregate in concrete and its advantages are discussed here. Due to ever increasing plastic pollution and construction waste pollution, it has become important to find a way for reducing such waste as it is hazardous to the environment. Plastic bottle is considered as a urban junk with sustainability characteristic which can be used as a material instead of some conventional material such as brick in building in construction. This paper intends to investigate the application of plastic bottles as one of the urban wastage in construction and that how it can lead to sustainable development. M25 design mix casted in which threaded plastic bottles filled with concrete made of using fly ash, coarse aggregates with plasticizer. Plastic bottles are cut into threaded forms. In due course of time, threaded plastic bottles evenly placing in layers into concrete cubes as micro level reinforcement. Later on its compressive strength, split tensile strength, flexural strength are tested. To overcome the above problems of over exploitation of natural resources and environmental issue due to the use of non-biodegradable plastic bottles, attempt has been made to use threaded plastic bottles in concrete. Use of threaded plastic bottles will reduce environmental waste. Hence it also proves to be cost effective.

Author Keywords. M 25 concrete cubes, Threaded Plastic Bottles, Fly ash, Sand, Coarse aggregates, Ordinary Portland Cement (53 Grade)

USE OF BRICK DUST AND FLY ASH AS A REPLACEMENT OF FINE AGGREGATES IN SELF COMPACTING CONCRETE. #223

Manpreet Singh and Satgur Singh,

Department of Civil Engineering, Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA) dullat.mani@gmail.com

Abstract

Self-compacting concrete principle is not new; special applications such as underwater concreting have always required concrete, which could be placed without the need for compaction. In such circumstances vibration was simply impossible. Early self- compacting concretes relied on very high contents of cement paste and, once supper plasticizers become available, they were added in the concrete mixes. The required specialized and well-controlled placing methods in order to avoid segregation, and the high contents of cement paste made them prone to shrinkage. The overall costs were very high and applications remained very limited. Compared to normal vibrated concrete (NVC), self-compacting concrete (SCC) possesses enhanced qualities and improves productivity and working conditions due to the elimination of compaction. SCC generally has higher powder content then NVC and thus it's necessary to replace some of the cement by additions to achieve an economical and durable concrete. Japan has used self-compacting concrete (SCC) in bridge, building and tunnel construction since the early 1990's. In the last five year, a number of SCC bridges have been constructed

in Europe. In the United States, the application of SCC in highway bridge construction is very limited at very limited at this time. However, the USA precast concrete industry is beginning to apply the technology to architectural concrete. SCC has high potential for wider structural applications in highway bridge construction. The application of concrete without vibration in highway bridge construction is practically admissible. In the present study, attempt has been made to compare the mechanical properties of self-compacting and normal concrete specimens. The criteria used in it based on 7days, 28 days and 56 days compressive, splitting tensile and flexure strength and of conventional and self-compacting concrete for five Fly ash & Brick dust ratios as a replacement to fine aggregate.

Author Keywords. NVC; SCC; fly ash

TREATMENT OF UNDERGROUND CAVITIES USING HYBRID CEMENT GROUT MIXES FOR HOUSING SUBURB IN NORTH-WEST PART OF PUNJAB STATE OF INDIA. #224

Manpreet Singh and Satgur Singh,

Department of Civil Engineering, Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA) dullat.mani@gmail.com

Abstract

Expansive sinkholes appeared in a housing suburb in North-West part of Punjab in Republic of India which leads to prompting annihilation of properties and along these lines to halfway clearing of this local location. From completely led examination programs, the sinkholes were credited to the presence and spread of Karst cavities in the limestone bedrock layer. In consequence, an entire treatment program was adjusted to lessen the danger of sinkhole repeat by limiting the conceivable outcomes of crumple in the upper dimension holes inside the limestone bedrock. In this treatment, two distinctive concrete grout blends were planned and utilized for treatment of the Karst cavities; Cavity filling grout and penetration grout. The appraisal of the utilized blends included standard assessment of the compressive quality, droop, warm conductivity, warm obstruction, dying, and air content, loss of droop, stream and setting time. The treatment was trailed by an assessment program by penetrating control boreholes. A few centers of the solidified grout were extricated from the control boreholes and their properties were assessed and contrasted with those of research facility examples. This paper depicts distinctive sorts and blends of concrete grouts used in the ground treatment, components of value control program, and recurrence and kinds of tests. Appraisal of the outcomes notwithstanding outline of the venture is likewise introduced. The outcomes confirmed the productivity of the diverse bond grout blends utilized in this treatment.

Author Keywords. Cement Grouts, North-west Part of Punjab, Sinkholes, Karst

Topic: Building Construction Technical Session V-B (28th.June)

USE OF TDR – TIME DOMAIN REFLECTOMETRY – FOR MEASURING MOISTURE CONTENT IN BUILDING WALLS. #84

Teresa Stingl Freitas[1], Ana Sofia Guimarães[1], Vasco Peixoto de Freitas[1]

1Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (tsf@fe.up.pt; anasofia@fe.up.pt; vpfreita@fe.up.pt)

Abstract

Measuring moisture content in building materials is crucial for the correct diagnosis of buildings pathologies, for the adoption of appropriate intervention measures and for the efficiency evaluation of the treatment solutions applied. There are several different techniques available to measure the moisture content in building materials. However, it still remains a great challenge to perform those studies in building walls, especially in a minor-destructive way and with continuous moisture content measurements along the walls thickness. In this paper, the suitability of the TDR technique was tested on two limestone prototype walls. Each wall was equipped with four TDR probes, designed with the same length of the wall thickness. To overcome the difficulty pointed out by several authors to the use of TDR in hard materials, a steel auxiliary guide was developed. The preliminary results suggest that the TDR technique is suitable for moisture content monitoring in consolidated porous building materials.

Author Keywords. TDR, moisture content, minor-destructive technique, building walls.

UNDERSTANDING CONSTRUCTION WASTE FROM PRODUCTION PERSPECTIVES. #128

Mahmoud Karaz[1] and José Teixeira[2].

[1] Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Minho, Campus of Azurém, 4800-058 GUIMARAES, Portugal (krraz_09@yahoo.com) ORCID 0000-0003-3063- 4998

[2] Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Minho, Campus of Azurém, 4800-058 GUIMARAES, Portugal (jct@civil.uminho.pt) ORCID 0000-0001-6694- 4926

Abstract

Among the existing efficiency in construction industry waste is criticized for its negative environmental, economic and social impacts. However, the concept of waste has led to establishing Toyota Production System (TPS) derivative lean production, which has been adapted to the construction. The understanding of lean principles within construction arenas has gain popularity, but the current practice still confronted with resulting waste in production. This paper holds a theoretical review to develop an understanding of the transformation of lean manufacturing into the construction context. This research provides a conceptional framework for practitioners to adopt the synergies of Lean and BIM by applying the fundamental production theories.

Author Keywords. Waste, Lean Construction, Design, Production, Manufacturing.

DEVELOPMENT OF HYGROTHERMAL ACCELERATED AGEING CYCLES. #180

Joana Maia[1], Nuno Ramos[2], Rosário Veiga[3]

1CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (joanamaia@fe.up.pt) ORCID 0000-0001-5036-8581
2CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt) 0000-0002-5331-7429
3LNEC, Av. Brasil, 101, 1700-066 LISBOA, Portugal, (rveiga@lnec.pt) ORCID 0000-0002-7135-8603

Abstract

The lack of durability assessment procedures directly applicable to thermal mortars motivated the development of durability assessment procedures. The combination of the analysis of existing procedures with hygrothermal simulation allowed the development of accelerated ageing hygrothermal cycles, applied to thermal rendering systems, taking into account the European climatic context, throughout a theoretical algorithm. The results contribute to the development of durability assessment methodologies directly applicable to thermal mortars.

Author Keywords. Thermal mortars, Durability, Accelerated ageing, Numerical simulation.

A PROPOSAL FOR USABILITY ASSESSMENT OF VISUAL IMMERSIVE SYSTEMS FOR CIVIL ENGINEERING EDUCATION. #80

Fábio Dinis[1], João Poças Martins[2], Fernanda Sousa[3], Bárbara Rangel[4],Ana Sofia Guimarães[5]

1Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (fabio.dinis.miec@gmail.com) ORCID 0000-0003-4017-7962
2 (jppm@fe.up.pt) ORCID 0000-0001-9878-3792
3 (fcsousa@fe.up.pt) ORCID 0000-0001-8428-7704
4 (brangel@gcloud.fe.up.pt) ORCID 0000-0002-5911-9423
5 (anasofia@fe.up.pt) ORCID 0000-0002-8467-6264

Abstract

Human-computer interactions in the AECO sector may be improved through alternative approaches such as the implementation of immersive applications (Meža, Turk, and Dolenc 2015; Paes, Arantes, and Irizarry 2017; de Klerk et al. 2019). However, there is a lack of common frameworks and procedures to assess the usability issues that may arise from the application of such immersive systems (e.g., Virtual Reality (VR), Augmented Reality (AR)). Thus, the present work proposes a methodology and guidelines to conduct usability assessments for Civil Engineering Education.

Principal Component Analysis (PCA), a multivariate data analysis methodology, was used to ascertain the possibility of reducing the dimensionality of the problem (usability attributes), i.e., to find a few set of new variables, denominated principal components, able to well explain the correlations between the original observed variables in terms of their correlations with a smaller set of new variables.

Results confirm that the initial set of variables is hardly replaced by a smaller number of principal components, hence lacking a sufficiently strong relation. Furthermore, the authors suggest presenting univariate and bivariate measures to

be able to establish future comparisons relating these attributes and other immersive systems.

Author Keywords. Civil Engineering Education, Usability, Immersive, Assessment, Virtual Reality, Augmented Reality.

CORE SUSTAINABILITY INDICATORS FOR FUTURE-PROOFING AND MONITORING OF THE ECONOMIC AND ENVIRONMENTAL LIFE CYCLE PERFORMANCE OF BUILDINGS. #99

Rodrigo Dourado[1], Nuno Almeida[2], Filipa Salvado[3], Ricardo Teixeira[4], Álvaro Azevedo[5]

1Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (rodrigo_dourado@hotmail.com)
2Department of Civil Engineering, Architecture and Georesources, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (nunomarquesalmeida@tecnico.ulisboa.pt) ORCID 0000-0003-1970-4553
3Nacional Laboratory of Civil Engineering (LNEC), Av. do Brasil 101, 1700-066 Lisboa, Portugal (asalvado@lnec.pt)
4 Laboratory of Robotics and Engineering Systems (LARSyS), Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (ricardo.teixeira@tecnico.ulisboa.pt) ORCID 0000-0003-3451-0458
5Nacional Laborato

Abstract

The investment on building projects considerably mobilizes both financial and environmental resources during long timespans. It is increasingly important for the Architecture, Engineering and Construction (AEC) practitioners to justify both the capital investments in this type of projects and the subsequent expenditures over the years. But the information relating to the economic and environmental performance of buildings assets over their life cycle is not readily available nor properly organized (Anand & Amor 2017; Salvado et. al 2018). This study aims at overcoming this significant limitation and facilitate the widespread incorporation of economic and environmental information into the decision-making processes of the AEC sector, namely in procurement environments.

This study seeks to establish an indicator-based joint approach for future-proofing and monitoring the economic and environmental life cycle performance of building projects. It builds upon previous experience in setting combined conceptual frameworks within the construction sector (Salvado et. al 2018; Almeida et. al 2015) and seeks to facilitate compliance against requirements of relevant international and European standards (e.g. ISO 41000, ISO 55000, ISO 21929-2, ISO 15686-5, EN 15643, EN 15221) and applicable regulations (e.g. European Directive 2014/24/EU), plus the incorporation of state-of-the art developments in the fields of Building Management, Life Cycle Costing and Life Cycle Assessment. The proposed topic is transdisciplinary and involves complementary background knowledge on civil engineering, environmental sciences, data management, industrial ecology and economics.

The method of this study is as follows: i) literature review and gap analysis towards integrating the economic and environmental information of buildings throughout their life cycle; ii) establishment of core economic and environmental sustainability indicators for the AEC sector on the life cycle performance of building assets and asset systems; and iii) development of databases that feed the set of indicators for specific types of building projects.

Author Keywords. Indicators, economic performance, environmental performance, life cycle, building projects, construction.

A SYSTEMATIC REVIEW BASED ON THE BIBLIOMETRICS INDEXES FOR DEVELOPING A RESEARCH TOPIC. #118

Andréa R. Souza[1], Ana Sofia M. S. Guimarães[2], Nuno M. M. Ramos[3]

[1]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (andrearesende.s@gmail.com) ORCID 0000-0001-6575-2527
[2]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (anasofia@fe.up.pt) ORCID 0000-0002-8467-6264
[3]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (nmmr@fe.up.pt) ORCID 0000-0002-5331-7429

Abstract

Despite the increasing availability of information in digital databases of scientific articles, in most cases, this information needs to be systematised, since they are currently carried out by a narrative or "convenience" method. The present meta-analysis proposes an observation of the possible universe for the research of the subject, based on the concept that the researcher is new in the area, that needs to develop ability in the analysis of magazines, authors and even of concepts, not being based only on assumptions already made. The proposed methodology proved to be effective in delimiting a spectrum of research, limiting Despite the increasing availability of information in digital databases of scientific articles, in most cases, this information needs to be systematised, since they are currently carried out by a narrative or "convenience" method. The present meta-analysis proposes an observation of the possible universe for the research of the subject, based on the concept that the researcher is new in the area, that needs to develop ability in the analysis of magazines, authors and even of concepts, not being based only on assumptions already made. The proposed methodology proved to be effective in delimiting a spectrum of research, limiting the initial search for articles relevant to the study of art.

Author Keywords. Research methodology, Systematic review, State of the art, Bibliometric index.

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FULL ABSTRACTS

Assessment of the long term dynamic behavior of innovative railway track solutions

Ana Luísa Ramos, António Gomes Correia [2], Pedro Alves Costa[3], Rui Calçada[4]

[1]Departmento de Engenharia Civil, Escola de Engenharia, Universidade do Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (id6629@alunos.uminho.pt)
[2]Escola de Engenharia, Universidade do Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (agc@civil.uminho.pt)
[3]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (pacosta@fe.up.pt)
[4]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ruiabc@fe.up.pt)

Abstract
The study and "*assessment of the long-term dynamic behavior of innovative railway track solutions*" pretends to understand the performance of railway systems and compare the long-term performance of the ballasted and slab tracks, mostly in transition zones. This study can help in the prediction and control of the long-term behavior of railway structures, which can lead to a reduction in the operations and maintenance costs, through the implementation of innovative solutions with impact on the whole system.

Author Keywords. ballasted and slab tracks, numerical model, long-term performance

1. Introduction

The study of the long-term performance of railway structures implies, firstly, to understand the concept of the ballasted and slab tracks, as well as the main similarities and differences. These two structures present significant differences in terms of maintenance, environmental aspects, track life-cost and materials. The behavior of the ballasted track is dependent on the performance of the ballast and also sub-ballast, while the slab track is dependent on the concrete slab and a support layer (Ramos et al. 2018). In this work, the performance of both structures is more focused on the behavior of the subgrade, which is a common element to both tracks.

2. Numerical modelling

2.1. 2.5D model

The dynamic analysis of the vehicle-structure-foundation of the ballasted and slab tracks can be obtained through the use of 2.5D and 3D models. The 2.5D formulation supported by the FEM-PML approach presents several advantages: an efficient computation proceeding and considers the 3D characteristics of the problem. However, demands two important conditions: the cross-section is invariant and the response of the structure is linear (Alves Costa et al. 2010). Indeed, the 2.5D models cannot be used to model the transition zones, which are important areas on the railway's network because of its accelerated degradation process. In this case, the 3D models are more suitable, but, at the same time, more demanding computationally.

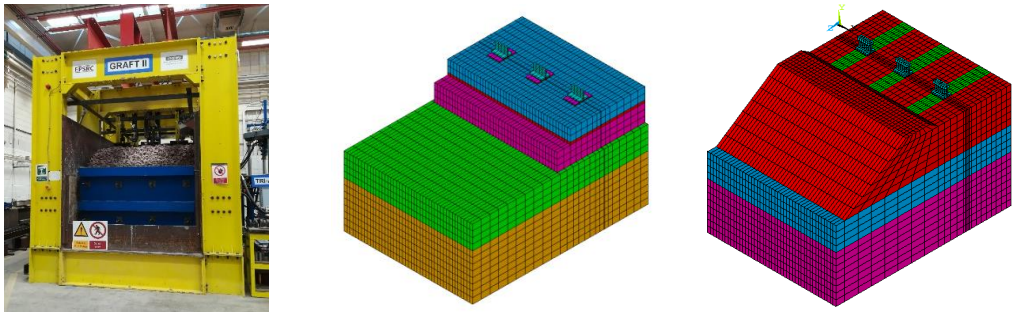
The long-term behavior of the ballasted and slab tracks can be studied through the application of the 2.5D formulation. In this case, the principal stresses are obtained and used to determine

the mean and deviatoric stresses, which are the main inputs of the permanent deformation empirical models that establish a relationship between the permanent deformations, number of load cycles and or a combination of both. This method is very expedited and, in the end, it is possible to obtain the cumulative permanent deformation of each structure and compare the performance.

2.2. Numerical model validation (3D models)

After understanding the long-term performance of each structure (ballasted and slab tracks), the numerical model validation is a very important stage to gain more confidence in the numerical results. Only after the validation, it will be possible to evaluate the long-term performance of the railway lines in the transition zones and optimize the system. The numerical model validation was performed considering the experimental data from the full-scale GRAFT-2 facility placed at *Heriot-Watt* University (Figure 1a). This test allows to assess and characterize the short and long-performance through the simulation of the passage of years of train passage in a few days of testing. The facility uses six independent hydraulic actuators loading three full-sized sleepers in the ballasted and slab tracks considering a phase loading (Čebašek et al. 2018).

The numerical model validation includes the calibration of rail's displacements, sleeper and slab's displacements, stresses and permanent deformations. The 3D numerical models of the slab and ballasted tracks are depicted in Figure 1b and Figure 1c, respectively.



a) b) c)

Figure 1: GRAFT-2 facility (a); 3D slab track model (b); 3Dballasted track model (c)

3. Discussion

Each stage in terms of numerical modelling is a step to try to obtain the long-term performance of railway tracks. The 2.5D models are extremely important since allows to obtain expeditiously the stresses and strains and understand the effect of the passage of the train in the materials considering the quasi-static and also the dynamic mechanisms (irregularities on the track). However, since the main goal of this work is to analyze the performance of the railway tracks in transition zones, the 3D models are required. In this stage, the calibration process is essential in order to calibrate not only the materials properties (E, ρ, ν and damping) but also the material constants of the permanent deformation empirical model. This study corroborates with the 2.5D results and allows gaining more confidence in the numerical results.

4. Future works

The future works include the conclusion of the 3D calibration of the ballasted and slab tracks, which includes the results of the receptance tests and stress results. Furthermore, the future works also include the modelling of the transition zones and the optimization of the system through the introduction of some modifications on the geometry, materials, etc.

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Acknowledgments

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Damage identification based on dynamic indicators of the train-bridge system

Andreia Meixedo[1], Diogo Ribeiro[2], João Santos[3], Rui Calçada[1]
[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ameixedo@fe.up.pt, ruiabc@fe.up.pt)
[2]Departamento de Engenharia Civil, Instituto Superior de Engenharia do Porto, Rua Dr. António Bernardino de Almeida, nº431, 4249-015 PORTO, Portugal (drr@isep.ipp.pt)
[3]Laboratório Nacional de Engenharia Civil, Avenida do Brasil, nº101, 1700-066, Lisboa, Portugal, (josantos@lnec.pt)

Abstract

The maintenance of bridges is central to the structural integrity and cost-effectiveness of any transportation system and therefore early damage detection plays a central role in any maintenance program (Carey et al.,2013). However, in the case of railway infrastructures, their intense use by frequent and heavy traffic makes the task of detection and possible repair of damaged sections problematic. Additionally, although most bridges are assessed via periodical visual inspections, they are expensive, scattered in time and prone to error, which allows to vibration-based SHM techniques to emerge, mainly on large newly built bridges (Cantero & Base, 2015). Early warning systems that minimize the disruption of the network are desirable and useful (Huang et al., 2012).

This work aims at applying vibration-based damage-identification methodologies capable of automatically extracting meaningful information related to the railway bridges' condition, from the great amounts of SHM data acquired nowadays from monitored structures. The idea is to take advantage of the fact that vehicles of known axle configuration cross the bridge regularly, that normally only one train is on the bridge at a time and that the relative positioning of the loads does not change. Additionally, it is important to develop a methodology able to detect damage based on responses that can be measured without interfering with the normal service condition of the structure (Obrien, 2013).

The revision of the SHM literature has allowed concluding that the SHM techniques, which are more appropriate to fulfill this goal, are those based in statistical learning, particularly the forward SHM techniques (Farrar. & Worden, 2013, Santos, 2014). In this sense, robust and adaptive algorithms for damage sensitive features extraction and selection based on autoregressive models are being developed, as well as techniques for feature classification. Specifically, the performance of the AR models as damage-sensitive features extractors is evaluated by applying these models to a several accelerations and displacements responses measured and simulated.

In order to identify damage based on the bridge responses during the train passage, an on-line monitoring system was installed at the railway bridge over the River Sado. The system aims at accomplishing a cost-efficient on-line SHM covering the majority of the structure's vulnerabilities by measuring accelerations, displacements, strains and temperatures. Given the goal of a real-time and continuous SHM, in addition to the network sensors, the hardware and software components were carefully defined. The long-term information obtained allows the validation of the methodology developed with a real-world case study.

With a calibrated numerical model of the railway bridge over the Sado River, different single and multi-damage scenarios are being simulated, with different levels of severity and in different locations. The damage identification methodology is being applied considering the bridge response with a single Alfa Pendular train travelling on the bridge deck, simulated by moving loads. In this sense, the numerical model of the bridge is being used to define the SHM system properties, to confirm the usefulness of the AR models to extract damage-sensitive features and to evaluate the classification

performance of the techniques based on outlier analysis and ANN algorithms.

Author Keywords. Structural Health Monitoring, damage detection, dynamic performance indicators, autoregressive models, train-bridge system, soft computing

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An innovative Bridge Management System: Application to a Portuguese Railway Bridge

João Fernandes[1], José C. Matos[1], Daniel V. Oliveira[1], António Abel Henriques[2]
[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (id5709@alunos.uminho.pt)
[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (jmatos@civil.uminho.pt)
[1]University of Minho, ISISE, School of Engineering, Guimarães, Portugal (danvco@civil.uminho.pt)
[2] University Porto, CONSTRUCT, Faculty of Engineering, Porto, Portugal (aarh@fe.up.pt)

Abstract
Bridges are one of the most important assets on the railway infrastructures. In Portugal, IP- Infrastruturas de Portugal is the company responsible to manage the railway infrastructures of Portugal. Along their lifetime, infrastructures are subjected to several degradation processes that may compromise their functionality. Therefore, it is necessary to establish management strategies to keep their functionality, but considering the budgetary constraints. In this extended abstract, it is intended to exemplify an application of a bridge management system (BMS) of a railway bridge in Portugal with a brief discussion of all the modules composing a management system.

Author Keywords. Bridges, Deterioration Models, Maintenance and Rehabilitation, Optimization.

1. Introduction

According to ISO 55000 (ISO55000 2014), Asset Management (AM) can be defined as "co-ordinated activity of an organization to realize value from assets". There are a wide range of definitions of AM depending on the field of evaluation. This paper intends apply the concept AM to a Portuguese railway bridge.

2. Materials and Methods

Figure 1 intends to show the methodology of work applied for this extended abstract.

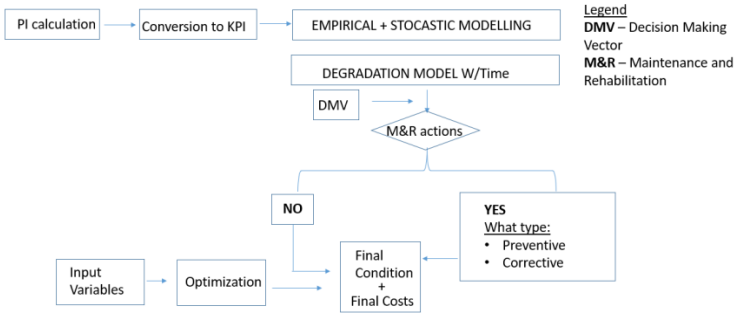

Figure 1 – Methodology of work

3. Discussion

The methodology is intended to apply to a deck of a RC and pre-stressing bridge.

3.1. Key Performance Indicator calculation

The key performance indicator (KPI) adopted for this case study was the reliability index. The type of analysis was an ultimate limit state (ULS) analysis considering flexure failure mode with the critical cross section at the middle span. For the calculation of the reliability index, the problem was solved adopting the Hasofer-Lind method obtaining a reliability index of around 5.0.

3.2. Degradation Models

After obtaining the reliability index, the process of deterioration was calculated as a combination of physical models (corrosion process) and Markov-Chain theory to address stochasticity. The final obtained curve is shown in figure 4.

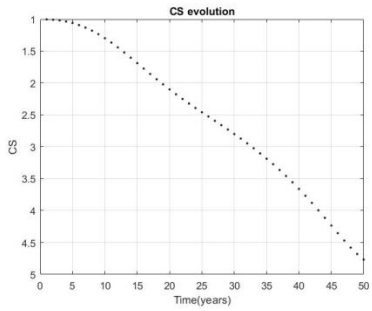

Figure 2 – Degradation curve

3.3. Optimization procedure

The optimization problem was applied to obtain optimal M&R solutions. Since the problem has two main variables, i.e. the KPI and cost, and being them conflicting each other, a multi-objective algorithm problem (MOP) based on genetic algorithms (GA) was employed. Figure 5 shows the pareto front with all the optimum solutions. As an example, 4 solutions based on the weights of the objectives were chosen.

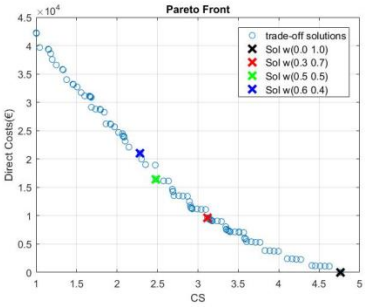

Figure 3 – Pareto front with optimal solutions

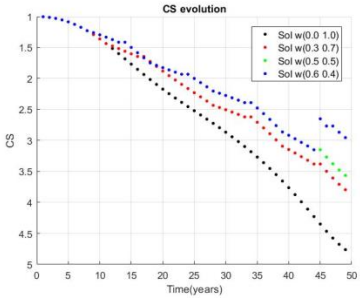

Figure 4 – Examples of possible optimal solutions

4. Discussion and Results

This extended abstract intended to show an overview of the methodology employed for this case study. Firstly, it was calculated the reliability index having obtained a value of 5.0 revealing a good condition of the structure. The next step concerned the calculation of the degradation of the infrastructure due to corrosion of the reinforcing steel and to finalize, a M&R scenario, through MOP, were conducted.

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Acknowledgments

The authors would like to thank to ISISE – Institute for Sustainability and Innovation in Structural Engineering and FCT – Portuguese Scientific Foundation under the iRail PhD program. The last author also like to thank to CONSTRUCT – Institute of R&D in Structures and Construction.

A novel approach for the condition monitoring of a freight wagon

José Neto[1], Pedro Montenegro[1], Rui Calçada[1]

[1]Construct, Department of Civil Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (up201002903@fe.up.pt; paires@fe.up.pt; ruiabc@fe.up.pt)

Abstract

Ensure a safe environment and a continuous sustainable operation system are key aspects for rail administrations and rolling stock companies. The schedule preventive interventions that are mandatory by the norms lead, in a significant number of times, to the replacement of fully functional components and, consequently, to unnecessary expenses. Furthermore, infrastructure managers are currently relying on inspection cars to assess the track geometry quality, leading to unnecessary constraints for the operation service administrators. Alternatively, these undesired restraints can be mitigated with the implementation of an on-board monitoring system in in-service vehicles. It is a reliable and non-invasive system capable of identifying both track and train operation conditions.

This paper starts with a short explanation of the developed monitoring system. It was implemented on an in-service freight wagon that operates in the *Beira Alta* line, collecting over 200km of data information. Then, a brief description of the numerical models of the track and the freight train are presented. Subsequently, the vehicle-track interaction problem is solved and the responses are compared with the experimental ones. The comparison results revealed a high level of accuracy, even before the calibration process. Finally, an inverse dynamic model is proposed and applied to the numerical problem, showing good results regarding the prediction of the wheel-rail interaction forces.

Author Keywords. Condition monitoring, inverse model, wheel/rail contact forces, on-board monitoring systems

Numerical Assessment of the Structural Behaviour of Two Stone Masonry Arch Bridges under Railway Loading

Rúben Silva[1], Cristina Costa[2], António Arêde[3]
[1]CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal (up201607996@fe.up.pt) ORCID 0000-0002-5809-7971
[2]CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal and Polytechnic Institute of Tomar, TOMAR, Portugal (c.costa@ipt.pt)
[3]CONSTRUCT-LESE, Faculty of Engineering (FEUP), University of Porto, University of Porto, PORTO, Portugal (aarede@fe.up.pt)

Abstract
In this paper is presented a numerical strategy for the structural assessment of existing railway masonry bridges. This strategy is based on continuous homogeneous finite element models, where an equivalent continuum is defined with characteristics that allow the description of the global behavior of the masonry components as a composite material. A Drucker-Prager model is adopted for the simulation of the nonlinear behaviour of both masonry and infill material. This structural assessment strategy is applied to two case study bridges, comprising the numerical assessment of their load-carrying capacity.

Author Keywords: Stone masonry bridges, railway loading, material parameters, FE numerical modelling

Type: Oral Communcation
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1. Introduction

Masonry arch bridges represent a significant percentage across the European railway networks. In Europe, masonry arch bridges are the most common railway bridge typology, and about 65 % of these bridges are older than 100 years and almost 75 % have spans less than 10 meters. Specifically, in Portugal, the number of masonry bridges represents 33% of the bridge stock, and the vast majority of masonry bridges, 79%, are short span bridges (SB, 2007).

These bridges are characterised by its high durability, and its structural complexity, mainly by the heterogeneity of its constituent materials. Numerical modelling strategies allow evaluating the structural response of these bridges with realistic service and limit loading conditions, settlements, material and structural composition, thus contributing to help in the assessment of the bridge condition and in the implementation of suitable management plans.

2. Bridges Description

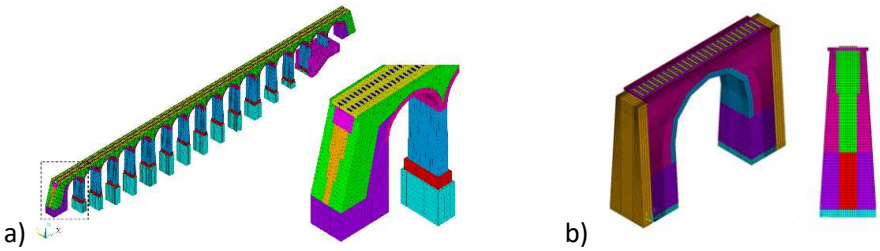
The bridges, built in granite stone masonry, are located in Minho railway line connecting Porto to Spain, and date back to late 19th century. The Durrães viaduct, a multi-span bridge, with 16 arches with 9 m span, totalizing 178 m total length, and the Leça bridge, a single arch bridge, with a span of 16 m, 18 m high and 5.31 m width.

3. Methodology

A nonlinear modelling strategy resorting to FE continuous homogeneous models is applied to the case study bridges. The constitutive material parameters are defined based on the results of an experimental campaign covering material testing for characterization of masonry and infill components of these bridges (Arêde, 2017). A Drucker-Prager model is adopted for the simulation of the nonlinear behaviour of both masonry and infill material.

3.1. 3D Global Models

The numerical models of the bridges are three-dimensional finite element discretization developed in ANSYS software (ANSYS, 2017) as illustrated in Figure 1. In these models, each structural component of the bridges is individualized. The masonry elements were modelled using a homogeneous composite material with equivalent mechanical properties so as to reproduce the properties of the assembly formed by stone blocks and mortar.

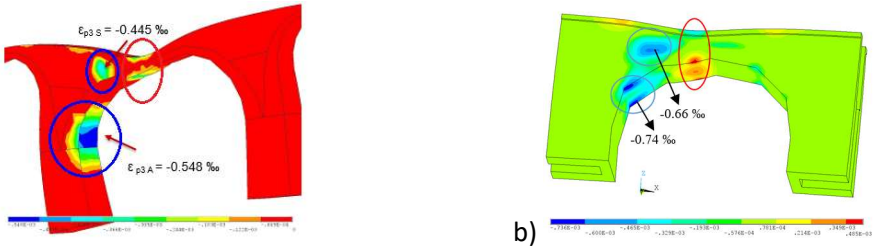


a) b)

Figure 1: 3D FE global models of the bridges: a) Durrães and b) Leça.

4. Results and Discussion

The response of the bridges' nonlinear models is evaluated for different intensity load levels (multipliers) of the LM71 load pattern. The evolution of the structural response of the 3D FE models concerning the effect of the dead load and the vehicle load is performed for different levels of incremental intensity of the vertical load pattern. Figure 2 shows the state of plasticity in terms of its principal components in the bridge sub-models for the maximum load applied. The analysis of the bridge response allowed recognizing two vulnerable zones influenced by both basic failure modes of stone arch bridges: the hinges mechanism in the arch and the crushing and out-of-plane of the spandrels.



a) b)

Figure 2: Principal minimum plastic strains in the bridges deformed configurations for the maximum intensity level applied: a) Durrães and b) Leça.

5. Conclusions

The adopted modelling strategies were applied to the bridges nonlinear models for its load-carrying assessment, providing good results. The numerical responses of the bridge under dead-load and incremental vertical forces were evaluated and allowed to simulate the failure modes of the bridges and the corresponding vertical loading.

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Non-destructive assessment method for stone masonry using ANN

Rachel Martini[1], Jorge Carvalho[2], António Arêde[3], Humberto Varum[4]
[1]PhD student, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (martini.rachel@fe.up.pt) ORCID 0000-0002-2639-0532
[2]Assistant Professor, CERENA – Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jorcarv@fe.up.pt) ORCID 0000-0001-6615-9872
[3]Associate Professor, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (aarede@fe.up.pt) ORCID 0000-0002-0901-2214
[4]Full Professor, CONSTRUCT-LESE – Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (hvarum@fe.up.pt) ORCID 0000-0003-0215-8701

Abstract
This work contributes to deepen the technical-scientific knowledge regarding the characterization of granite masonry based on geophysical, mechanical and neural networks techniques. For this purpose, a methodology based on non-destructive tests was used to characterize historical masonry and later to obtain information regarding the mechanical parameters of these elements. A mechanical characterization tool was developed resorting to Artificial Neural Networks (ANN). The database for the characterization was built using GPR, sonic and dynamic test results. The mechanical characterization was done by means of conventional uniaxial compression tests. For the construction and choice of the network architecture, 31 possible combinations of input data were defined, with a total of 122 trained networks. From all trained ANNs, based on the errors attributed to the estimated moduli of elasticity, networks with acceptable errors of up to 30% were selected.

Author Keywords. sonic test, dynamic test, GPR, compression test, artificial neural networks.

Type: Oral Communication
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1. Introduction

The rehabilitation of historic buildings is considered an important step for the preservation of historical heritage, be it global or national. For a well-grounded, lasting and with least possible damage rehabilitation process, non-destructive testing techniques (NDTs) are available, which help in obtaining characteristics of the object to be analyzed. For this work, the following NDTs are used: the Ground Penetrating Radar (GPR) method, sonic tests and dynamic tests. These techniques were applied in masonry panels, built in lab-controlled environment, with characteristics similar to existing historical buildings. Parallel to the application of NDTs, conventional uniaxial compression tests were made in the referred double-leaf granite stone masonry (DSM) panels. The obtained data were analyzed for correlation with the results of NDTs resorting to artificial neural networks (ANN).

2. Materials and Methods

Eight double-leaf stone masonry walls (DSM) were studied, divided into four types (Martini et al. 2018). The sequence of the work in the laboratory was performed in real scale masonry, using the parameters and techniques defined by the bibliography (Martini et al. 2016; Martini et al. 2017). The nntool GUI (Graphical User Interface) neural network interface instrument, available in MATLAB 7.6.0 (R2008a), was used to perform the data analysis of ANN.

3. Experimental tests

The information defined as network input data are the results of NDTs (Martini et al. 2016; Martini et al. 2017). The characteristics obtained with these tests, along with two geometric characteristics (presence of cross-block and surface characteristic - regular and irregular -) are the input variables; the output variable is $E_{20\text{-}40}$ (global tangent modulus of elasticity of the panels) obtained from the uniaxial compression test. The $E_{20\text{-}40}$ was defined based on the slope of the stress (σ) / strain (ε) plots, for the stress values between 20% and 40% of the maximum value of the applied stress (σ_{max}) for each DSM.

4. Analysis using ANN

ANN has fast processing and, after obtaining the expected results in the training and validation phase, the network can be used as an analysis tool without the need of remodeling. The data used must characterize the real structure situation because, since these are strictly mathematical techniques, the performance of the processing depends on the correctness of the feed data. Data normalization (dynamic test results, sonic tests and GPR) is also suggested, since the disparity between values may result in unsatisfactory network performance. The configurations defined for the network's creation were made based on the variation of combinations of the characteristics of the DSM (input data). Six combinations were defined according to the DSM features and nine combinations were randomly defined.

5. Conclusions

The ANN was used to mechanically characterize DSM with some variations. In addition, variations in input data and network architecture (number of neurons) were tested, with a total of 122 trained networks. The results highlight the importance of using these types of nondestructive tests for more efficient characterization of granite masonry structures. It was also possible to conclude that the increase in the number of neurons present in hidden layers leads to better network performance since all networks trained with only 5 neurons led to unsatisfactory values. In addition, the trained networks with only one input variable presented the highest error values. This corroborates the idea that synergy of tests is very important for the efficient characterization of granite masonry structures.

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Railway ballast behaviour of inert steel slag aggregate under monotonic and cyclic triaxial loading

Bruno Delgado[1], António Viana da Fonseca[2], Eduardo Fortunato[3]
[1]CONSTRUCT-Geo, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (brunogdelgado@hotmail.com)
[2]CONSTRUCT-Geo, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (viana@fe.up.pt)
[3]Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal (efortunato@lnec.pt)

Abstract
In the 21st century the environmental concerns have imposed new approaches to use of natural resources. Especially in Civil Engineering, the rational use of natural resources imposes itself as a new paradigm for conception, design and construction, justifying the research for alternative materials to those conventionally used in the railway industry, such as natural crushed rocks, for example.

This work presents the results of monotonic and long-term cyclic triaxial tests carried out on scaled down ballast specimens in a ratio of 1:2.5 from the ballast standard AREMA N. 24 (AREMA 2013). The mechanical behaviour of an inert steel slag ballast and of a granite ballast were compared. The cyclic tests were conducted in two different stress paths compatible with heavy haul loading. The steel slag ballast presented higher values of shear strength parameters and better deformability behaviour, expressed by higher values of resilient modulus, lower particle breakage, and a faster tendency for permanent deformation stabilization.

Keywords: Railway ballast behaviour, Triaxial tests, Steel slag ballast, Heavy haul loading.

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Cyclic Liquefaction Resistance from in situ and laboratory tests: modelling calibration for numerical applications

Catarina Ramos[1], António Viana da Fonseca[2], Matthew Coop[3]
[1]CONSTRUCT-GEO, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (catarinacorreiaramos@gmail.com) ORCID 0000-0001-6679-8121
[2]CONSTRUCT-GEO, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (viana@fe.up.pt) ORCID 0000-0002-9896-1410
[3]University College London, UK (m.coop@ucl.ac.uk)

Abstract
Earthquakes have been responsible for many human casualties and resulted in high economic and social damage. One phenomenon associated to this natural disaster is the liquefaction of soils, which can have devastating consequences. The purpose of this work is to deepen the studies in cyclic liquefaction as it is a problem of great importance especially when considering non-consensual factors. This study focuses on soils from an experimental site located in Lezíria Grande de Vila Franca de Xira, Portugal. The interpretation of a soil profile based on SPT and CPTu is presented and the laboratory work performed is briefly discussed.

Author Keywords. Liquefaction, in situ tests, laboratory tests.

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1. Introduction

Cyclic liquefaction associated with earthquakes is responsible for devastating disasters, so the study of soils susceptible to liquefaction is of extreme importance to refine methods and obtain more reliable results. The purpose of this work is to deepen the studies in cyclic liquefaction, through the performance and interpretation of in situ tests results with novel approaches to improve interpretation tools, the performance of advanced laboratory tests to evaluate the influence of critical factors and the numerical modelling of the sites. Herein, a brief description and interpretation of in situ tests and initial laboratory results are presented.

2. Experimental site and in situ tests

An experimental site in Vila Franca de Xira was selected based on the geological, geomorphological and seismic context of the region. At four specific locations, an extensive experimental campaign was conducted, including SPT, CPT, DMT and shear wave velocity measurements. Figure 1 shows one of the analysed profiles, including the SPT and CPTu results for the type 1 seismic action, interpreted with the methodology proposed by Boulanger and Idriss (2014). The profile is composed of sand and silt interlayers, making it difficult to identify the more liquefiable layers but at 6m to 7m the FS is clearly higher than 1 and 2m to 5m and 10m to 16m are critical layers with FS below 1. At each location, samples were retrieved, using the Mazier and Gel-Push samplers. Figure 1c shows an example of the depths at which samples were collected. The intact samples were transported carefully to the laboratory to be prepared for element tests using different apparatuses. The quality of the samples was assessed through visual evaluation and measurements of shear wave velocity and relative density. The characterization of the materials included grain size analysis, Atterberg limits and specific weight determination.

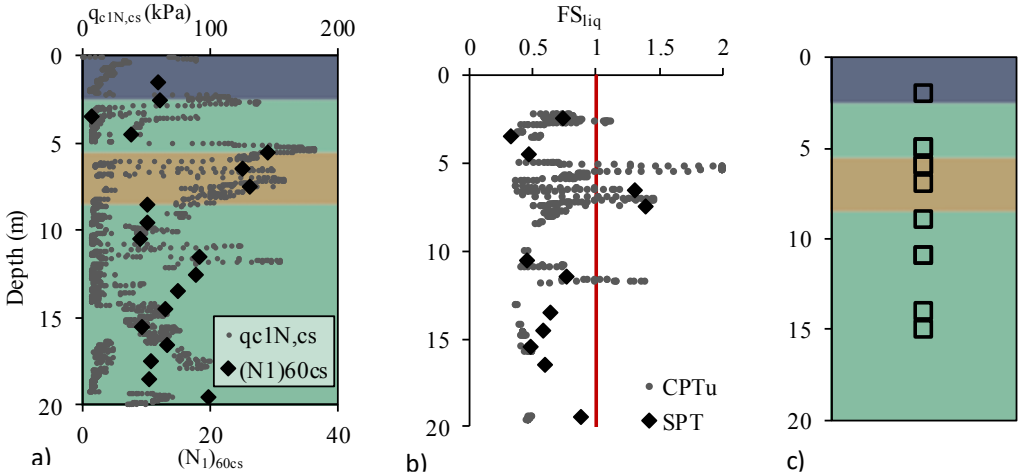

Figure 1: Soil profile analyses: a) simplified profile based on soil type and SPT and CPTu resistance parameters; b) Factor of safety against liquefaction; c) undisturbed samples collected

3. Laboratory tests

The work includes the detailed characterization of different soils collected (sands and silty sands) and the performance of a series of advanced laboratory tests on intact and reconstituted specimens, to evaluate the influence of fabric on the liquefaction susceptibility. Figure 2a and 2b present the results for a cyclic triaxial test, where liquefaction occurred at 48 cycles. Figure 2c shows the comparison of the pore pressure development of an intact and reconstituted specimen, tested under the same conditions, showing a good agreement of the two curves.

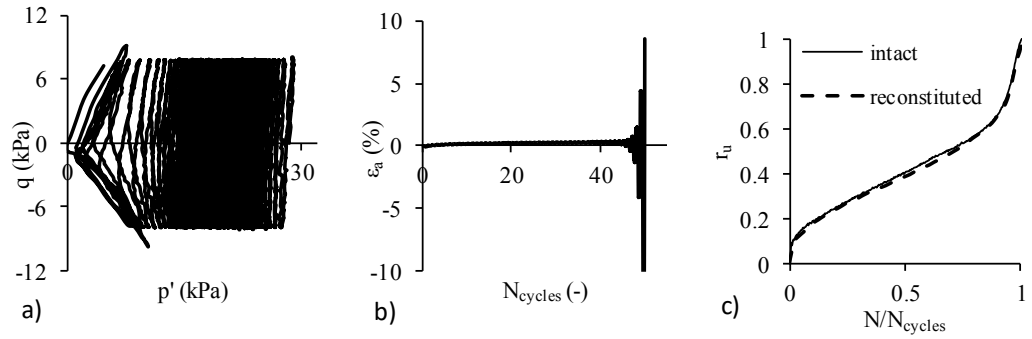

Figure 2: Cyclic triaxial test results: a) stress-path; b) axial strains; c) comparison between the pore pressure generation of an intact and reconstituted specimen

4. Conclusions

This work focuses on the initial part of a doctoral study, the performance and interpretation of in situ tests and some laboratory tests performed. The future developments include the performance of more laboratory tests to evaluate the influence of critical factors as sample preparation method (fabric), fines content, drainage and stress-path on soil behaviour and the numerical modelling of these sites conditions.

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Stabilization of Sediments with Geopolymers for Foundation of Coastal and Fluvial Structures

Claver Pinheiro[1], Sara Rios[2], Nuno Cristelo[3], António Viana da Fonseca[4]

[1]CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (clavergiovanni@gmail.com) ORCID 0000-0002-0402-1357
[2] CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (sara.rios@fe.up.pt) ORCID 0000-0002-2625-1452
[3]Departamento de Engenharias, Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados, 5000-801, Vila Real, Portugal (ncristel@utad.pt) ORCID 0000-0002-3600-1094
[4] CONSTRUCT-GEO, Universidade do Porto, Portugal, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (viana@fe.up.pt) ORCID 0000-0002-9896-1410

Abstract

The development of techniques currently used to increase the bearing capacity such as Deep Soil Mixing (DSM) makes possible the construction activity in places where the soil has weak geomechanical characteristics. However, this ground improvement techniques use large amounts of Portland cement (PC). For this reason, the number of research studies about the use of waste materials for soil improvement has increased. The alkaline activation (AA) technique can be very interesting for that purpose as it uses waste materials such as slags and fly ash. In comparison with cement-based binders, alkali activated binders (AA binders) have proved its technical and economic viability (Cristelo et al., 2012a; 2012b), but their application in specific conditions still needs to be studied. AA binders are expected to have lower cost-benefit ratio when used in contaminated or salted sediments when compared to PC grouts.

Thus, the aim of this research is to develop an alkali activated binder made of steel slag instead of PC, to be used in Deep Soil Mixing columns in coastal areas. The slag is mixed with an alkaline solution made with sodium hydroxide and sodium silicate creating a gel that binds the particles together and hardens with time. The first step of this research was the optimization of the binder using the Design of Experiments (DoE) methodology to maximize the mechanical resistance and to minimize their cost. The soil characterization with Cone Penetration Test (CPTu) and laboratorial tests (consolidated drained (CD) and consolidated undrained (CU) triaxial tests, grain size distribution and specific gravity) was carried out to understand the soil behaviour when mixed with the binder. The next step was to optimize the mixture of the binder with the soil, in terms of solids/liquid ratio and concentration of the alkaline solution. Then, the mechanical performance of the treated soil in the DSM columns was evaluated by simulating its properties in the laboratory following the EuroSoilStab (2002) precepts. Initially this was analysed by flexural and compressive strength tests in specimens cured under salt water. From the analysis of the results it was concluded that for non-submerged cure it is possible to use activators without sodium silicate and wet application is indicated (Wet Mixing). In cases of submerged curing it is necessary to use the sodium silicate, responsible for the initial hardening of the material, avoiding the leaching process. In this case it is indicated the dry application (Dry Mixing) that uses only the water contained in the soil that, if found in excess, prevents the necessary increase of resistance. It has been proven that even contaminated soils (with acid pH) below the water table and with low temperatures (around 18ºC) can be stabilized through alkaline activation.

Author Keywords: Deep Soil Mixing, Alkaline Activation, Soil Improvement

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Stress-strain behavior from triaxial test on geogrid-reinforced aggregate-soil interface specimens

Gabriel Marchi[1], Isabel Falorca[2]
[1]C-MADE, Departamento de Engenharia Civil e Arquitetura, Faculdade de Engenharia, Universidade da Beira Interior, Calçada Fonte do Lameiro, 6200-358 COVILHÃ, Portugal (gabriel.marchi.oliveira@ubi.pt) ORCID 0000-0001-8800-285X
[2]C-MADE, Covilhã, Portugal, (ifalorca@ubi.pt) ORCID 0000-0002-6681-2525

Abstract
The behavior of basal reinforced fills depends largely on the mechanical properties at the geogrid-reinforced aggregate-soil interface. These properties are derived through analysis and interpretation of deformation and load measurements during tests. Depending on the stiffness heterogeneity of the specimens, the deformed shape changes, and this is not typically considered when processing triaxial test data. Therefore, the approaches currently used to obtain stress-strain relations from triaxial compression test need more advanced knowledge of mechanics. This paper describes the equilibrium configuration of geogrid-reinforced aggregate-soil interface specimens under axisymmetric compression conditions and outlines a procedure for processing test data. The standard method is considered satisfactory for estimating stiffness gain with the reinforcement addition, since the initial height of the specimen is corrected using a method of homogenization.

Author Keywords. triaxial test, soil-geosynthetic interaction, basal reinforced fills

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1. Introduction

Geogrids are commonly used to reinforce the compacted aggregate layer placed on the surface of a soft subgrade and therefore such a construction cannot be treated as reinforced soil. The interaction between the reinforcing layer and the surrounding materials is of utmost importance as it strongly influences the transfer of load through the unpaved structure to its foundation. There is therefore a need to define the mechanical properties, as described by stress-strain relations, at the geogrid-reinforced aggregate-soil interface. Such relations could be derived from triaxial test data, after proper analysis. The objective of this paper is to compare and discuss the stress-strain relation obtained from the test data using different methods of interpretation and analysis.

2. Materials and Methods

Aggregate (crushed granite; median grain diameter D_{50} = 13.1 mm) and rubber–sand mixture (volume fraction of rubber particles V_{rubber} = 0.55; porosity of mixture n = 33%) were used as fill material and soft subgrade respectively. 3D-printed model geogrids with properly scaled dimensions and tensile behavior were used in the tests (**Erro! Fonte de referência não encontrada.**). The tensile strength was obtained from tensile tests (EN ISO 10319) with a strain rate of 1.0 mm/min. The specimens (100 mm diameter; 200 mm height) were prepared directly on the pedestal, using a membrane suction stretcher. The predetermined amounts of rubber–sand mixture and aggregate were placed at bottom and top half of the mould respectively, and the geogrid was placed at the interface between them. Standard

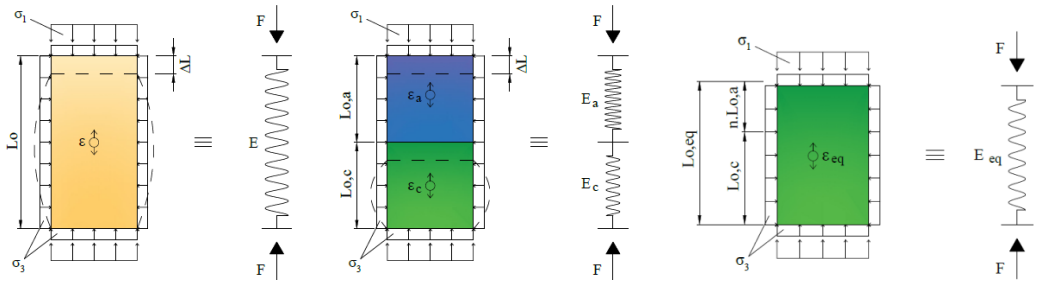
triaxial compression tests on cylindrical specimens were conducted at a constant axial deformation rate of 1.0 mm/min and a confining pressure of 30 kPa (BS 1377-7) applied by means of a partial vacuum as back pressure. The axial load was measured directly on the specimen by an internal load cell (16 kN) and the axial deformation was measured by an external LVDT (50 mm).

Material structure	Aperture size (mm x mm)	Rib height (mm)	Rib width (mm)	Tensile strength (kN/m)
PP (biaxial)	14 x 14	1.2	1.0	1.18

Table 1: Properties and characteristics of geogrids.

3. Discussion

The recorded load and deformation data can be converted to stress and strain data, through analytical assumptions, after a specimen deformed shape is assumed. Different from that of homogeneous specimens, the geogrid-reinforced aggregate-soil interface specimens exhibit bulging-type deformation in the bottom half when sheared, due to friction at both ends of the rubber–sand mixture (Figure 1: (a), (b)). Considering the non-uniform distribution of stress and strain within the specimen, a homogenization procedure to calculate them was proposed (Figure 1: (c)). Several observations can be made based on the calculated stress-strain relations. The approaches currently used (Head, 1992) and the proposed method give similar values for stress, but significantly different values for strain at which stress occurs.



(a) (b) (c)

Figure 1: Bulging-type deformation and model for a) homogeneous and b) heterogeneous specimen; c) homogenization model for heterogeneous specimen.

4. Conclusions

A homogenization method was proposed for processing triaxial test data, in order to define the stress-strain behavior of geogrid-reinforced aggregate-soil interface specimens. The study is under way to provide some insight into the interaction properties.

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Rotation capacity of steel members under cyclic loading

Anis Mohabeddine[1], J.A.F.O.C Correia[1], J.M Castro[1]
[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto

Abstract
The rotation limits of steel members are key modeling parameters and acceptance criteria for nonlinear analysis and performance assessment of steel moment-resisting frames. The rotation limits defined in Part 3 of Eurocode 8 (EC8-3) have been subject to a lot of discussion in the literature. This paper presents a numerical study on IPE steel beams subjected to cyclic loading. An advanced numerical model was developed in ABAQUS that accounts for the geometrical imperfections and is based on a comprehensive calibration of the material constitutive model. New rotation limits for the life safety limit state defined in EC8-3 are proposed. An empirical formulation based on regression analysis is derived for the evaluation of the rotation limits for different IPE sections.

Author Keywords: Rotation capacity, cyclic, IPE sections.

1. Introduction

Deep steel beams such as IPE sections are desired by design practitioners due to the high moment resistance and a great economy they provide. However, recent studies have shown that under cyclic loading these sections may exhibit limited ductility and rapid degradation. Ozkula et al [1] conducted experimental study to investigate the cyclic flexural behavior of deep beam-columns with steel cross section range from W24 to W36. Elkady and Lignos [2] provided thorough discussions on the seismic design of deep steel beam-columns under combined cyclic and axial loading. D'Aniello et al [3] conducted experimental test on European HE and IPE steel profiles under monotonic and cyclic loading. The members with IPE cross sections achieved lower ductility than HE sections and severe degradation. The comparison between monotonic and cyclic results showed that the rotation capacity obtained under cyclic loading are almost 30% of the monotonic ones. According to Anastasiadis et al [4], the Eurocode 8 classification as well as the behavior factor, q, are determined mainly from monotonic loading. Araújo et al [5] conducted numerical analysis on steel beams with IPE and HE profiles and demonstrated that EC8-3 overestimates the rotation capacity limits for slender sections. This study presents an evaluation of the rotation capacity of beams with IPE cross sections under cyclic loading using advanced numerical analysis in ABAQUS software.

2. Numerical model

A high-fidelity numerical model was developed in ABAQUS software. The model is validated with experimental results. It consists of a cantilever beam, fixed at one end and constrained in the out of plane direction on the other end in order to avoid out of plane displacements. The flanges are restrained to prevent lateral torsional buckling following the prescriptions of AISC 341-10 [6] . The geometrical imperfections are considered using the manufacturer tolerances (i.e. out-of-squareness and web off center) provided in EN10034 [7]. Very refined meshing with size equal to $b_f/24$ (i.e. b_f: flange width) is adopted, using quadratic shell S4R elements. The SAC cyclic loading protocol [8] has been applied on the free edge of the cantilever. The combined isotropic/kinematic hardening model was used. The model parameters were calibrated from experimental cyclic coupon tests of S235 and S355 steels [9]. Information regarding the calibration is available in Mohabeddine et al [10].

3. Rotation capacity limit

The cross-sections range IPE200 to IPE600 is covered in this study. New rotation limits corresponding to the "Life Safety" limit state as defined in EC8-3, are proposed. An improved

analytical formulation derived from regression analysis is presented in Equation (1), where, θ_LS stands for the rotations at peak moment in the cyclic backbone curve.

The equation provides an evaluation of the rotations using the geometrical and material properties as input. The variation of the plastic chord rotations for the different sections as well as the effect of web slenderness are presented in Figure 3-1.

$$\theta\_LS = 1.0935 \left(\frac{h}{t_w}\right)^{-0.6186} \left(\frac{b}{2t_f}\right)^{-1.2557} \left(\frac{L}{d}\right)^{0.5426} \left(\frac{f_y}{355}\right)^{-0.2440} \quad (1)$$

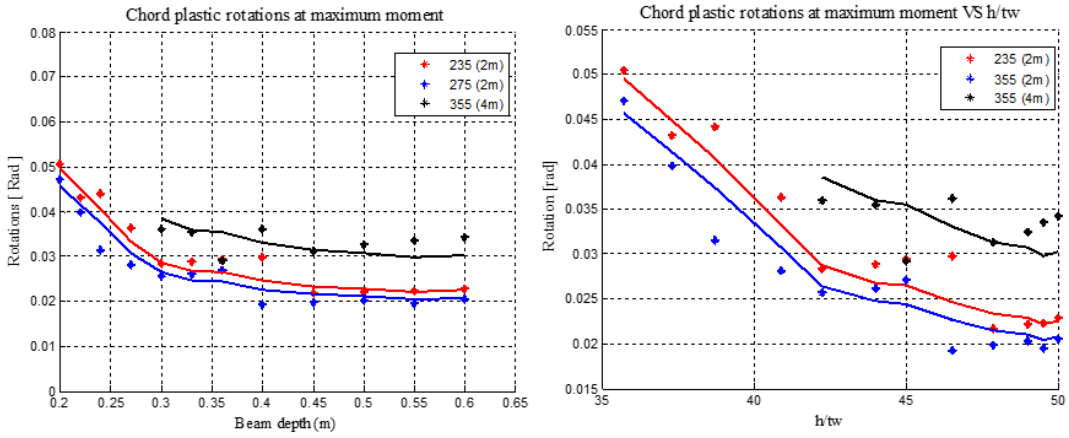

Figure 3-1: plastic chord rotation against web and flange slenderness

4. Conclusions

In this study, advanced FE analyses on steel beams under cyclic loading are conducted. The simulation is performed using a complex cyclic hardening material model comprehensively calibrated from experimental data[9]. A new improved analytical formulation for the evaluation of the EC8-3 rotation limits, is provided.

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Assessment of a railway bridge damaged under flood effects using a robustness-based approach

Edward Baron[1], Jose Matos[2], Rui Calçada[3]

[1]School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (id8033@alunos.uminho.pt)

[2]School of Engineering, University of Minho, Campus de Azurém, 4800-058 Guimarães, Portugal (jmatos@civil.uminho.pt)

[3]School of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 Porto, Portugal (ruiabc@fe.up.pt)

Abstract

One of the main goals of the iRail PhD program is the asset management of high capacity structures with accuracy and reliability. To achieve this principal objective, it is defined as a priority the innovation of methods to determinate the safety and extend the service life of rail infrastructures (i.e. railway tracks, bridges, …). Due to the importance of railway bridges for the network, it is necessary to assess the associate risk against natural hazards. This research consists in the assessment of flood effects (e.g. Scour) into the rail infrastructure. To achieve this, it is proposed a set of damage scenarios are introduced into a specific railway bridge typology. Thus, the outcome of the selected scour damages is computed using a robustness index, calculated by the variance of the structural reliability index due to the damage caused by the scour, allowing to quantify its impact in the structural safety. Namely a robustness-based approach assessment. Besides, the modelling process and the finite element analysis of the structure is performed using DIANA FEA software that allows the performance of probabilistic analysis based on non-linear behaviour of the structure. Thus, it will be established as a part of the general framework basis for quality control and damage identification for this specific hazard.

Author Keywords. Robustness, Scour, Railway bridges, Flood effects

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DESCRIPTION OF MONITORING CAMPAIGN IN AN ONSHORE WIND TURBINE IN TOCHA WIND FARM

J. Pacheco[1], F. Magalhães[1], C. Moutinho[1], S. Guimarães[2], L. Noites[3], A. Cunha[1], M. Marques[2], J. Carlos Matos[2]

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

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

[3]INEGI, Porto, Portugal

Abstract

In the context of the WindFarmSHM project a quite extensive experimental campaign is being performed in Tocha wind farm, an onshore wind farm located in Portugal. This includes the instrumentation of at least two wind turbines aiming the development, validation and optimization of monitoring strategies at the level of the wind farm for damage detection and fatigue analysis, using the response to operation loads measured by strain gages and accelerometers distributed in the tower and blades. The paper presents the experimental layout for one of the instrumented wind turbines, introduces the processing tools under development and shows some initial results. At this preliminary stage, it will be evaluated the ability of the different monitoring components to track the modal parameters of the system composed by the tower and the rotor.

Author Keywords. Wind Turbine, Dynamic Monitoring, Operational Modal Analysis.

1. Tocha Wind Farm

The main goal of the recently started WindFarmSHM research project is the development, validation and optimization of monitoring strategies to be applied at the level of the wind farm. The accomplishment of this goal implies the development of an experimental campaign involving the simultaneous instrumentation of several wind turbines in the same wind farm. This is being performed in an onshore wind farm, the Tocha wind farm, located in the central region of Portugal, in a flat terrain close to shore (see figure 1). It consists of five Vestas V100-1.8 MW wind turbines, with a 100m diameter, 3 blades rotor, supported by a 93.3m steel tower, clamped in a reinforced concrete slab supported by 16 concrete piles.

The most relevant properties of the wind turbines have already been determined with the performance of ambient vibration tests using portable equipment and a first numerical model in FAST has been developed.

Figure 1. Location of Tocha Wind Farm with distribution of the 5 wind turbines

2. Monitoring System

The research project includes the monitoring of 3 wind turbines, loaded by winds with different turbulence intensities motivated by the neighbouring wind turbines, during a period of about 2 years. In one of the wind turbines the following equipment has already been installed:

- 2 alternative systems to characterize the dynamic behaviour of the tower: a commercial system based on a set of very low noise accelerometers and a customized low-cost system based on MEM accelerometers designed and assembled in FEUP;
- a set of fiber optic strain gages to estimate bending moments at the blades roots;
- MEM accelerometers place at the blades, at 10 meters from the root, to characterize their dynamics;
- strain gages at the tower base to characterize the stresses during different operating conditions.

Complementary information about the wind characteristics and the turbine operation is provided by the SCADA system.

3. PRELIMINARY MONITORING RESULTS

The following figures show some preliminary results of the experimental campaign. In figure 2 a) a spectrum obtained from time series of accelerations registered at 3/4 of the height of the tower is represented, using the commercial system (KMI) and the low-cost system (MEM). Both spectrums refer to operating conditions and their shapes are very similar. The peaks corresponding to the first two pairs of tower bending modes and the respective mode shapes are accurately identified with both systems. Two-time series of extensions recorded at two diametrically opposed points of the tower are shown in Figure 2 b). During the represented period the rotor changes from an operating condition to a non-operating condition, being possible to identify not only the variation in the static bending but also the dynamic component associated with the first natural frequency of the tower. Finally, Figure 2 c) shows a power spectra derived from the strains time series recorded at blade for parked condition. Its peaks are associated with rotor modes, also identifiable with the acceleration sensors placed in the blades

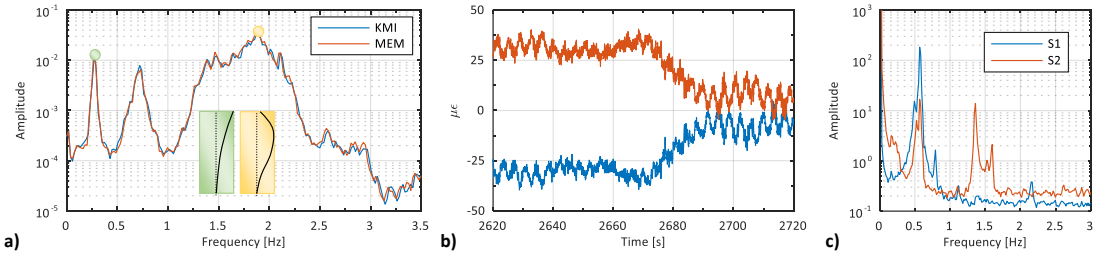

Figure 2: a) Spectra time series of tower. b) Tower strains time series. c) Spectra time series of blade strains

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Wave propagation in elastic cables: numerical simulation and assessment of dispersive behavior

João Rodrigues[1], Elsa Caetano[2], João Santos[3], Maria do Carmo Coimbra[4]
[1]CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jmcr@fe.up.pt)
[2]CONSTRUCT, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ecaetano@fe.up.pt)
[3]Structural Monitoring Unit, Structures Department, National Laboratory for Civil Engineering, Avenida do Brasil, 101, 1700-066 LISBON, Portugal (josantos@lnec.pt)
[4]LSRE-LCM, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (mcoimbra@fe.up.pt)

Abstract
The dynamic behavior of cables is usually analyzed by superposition of vibration modes. However, this methodology becomes ineffective when the wavelength of cable response is small relative to its length. In this study, a wave propagation model for elastic sagging cables is considered, and the corresponding system of partial differential equations is solved by the method of lines, allowing the characterization of coupled longitudinal and transverse deflections in finite, real cables. The numerical results thus obtained are used to compute time-frequency distributions in different sections along the cable length, permitting the assessment of dispersion relations for transverse group velocities.

Author Keywords. Cable dynamics, wave propagation, dispersion, partial differential equations, time-frequency analysis

1. Introduction

The structural design of cables requires an adequate characterization of their dynamic behavior. Most methodologies describe the general cable response as a superposition of contributions from vibration modes, which constitute standing waves. However, this approach becomes ineffective for applications involving very long cables or high order mode dynamics, since the disturbances propagating along the cable may be significantly attenuated before reaching its boundaries. As a result, some authors have developed an alternative methodology based on the study of propagating waves. Behbahani-Nejad and Perkins (1997) modeled an elastic, sagged and stationary cable as a one-dimensional continuum with negligible bending and torsional stiffness, and obtained analytical expressions for the free and forced response of an infinite-length cable, assuming a parabolic equilibrium profile.

2. Numerical Model

Following the linearized equations of motion presented in (Behbahani-Nejad and Perkins 1997), structural waves propagating in the static equilibrium plane decouple from those orthogonal to the plane. In-plane deflections, coupled by the effect of curvature κ, are obtained from the system of second-order, hyperbolic PDEs consisting of equations:

$$a_1 \frac{\partial^2 u_1}{\partial s^2} - (a_1 + a_4)\,\kappa\,\frac{\partial u_2}{\partial s} - a_4\,\kappa^2\,u_1 + \frac{F_1}{\rho\,A} = \frac{\partial^2 u_1}{\partial t^2} \quad \textbf{(1)}$$

$$a_4 \frac{\partial^2 u_2}{\partial s^2} + (a_1 + a_4)\,\kappa\,\frac{\partial u_1}{\partial s} - a_1\,\kappa^2\,u_2 + \frac{F_2}{\rho\,A} = \frac{\partial^2 u_2}{\partial t^2} \quad \textbf{(2)}$$

In these equations, u_1 is the tangential (longitudinal) displacement, u_2 designates the normal (transverse) displacement and s is the Lagrangian coordinate along the deformed cable length. Constants a_1 and a_4 depend on the propagation velocities of the longitudinal and

transverse waves, while F_1 and F_2 are components of an arbitrary external excitation. The quantity $\rho\ A$ represents the cable mass per unit length.

The system of PDEs (1) and (2) was solved by implementing the method of lines using MATLAB. After defining n points along the cable length, spatial derivatives were replaced by fourth-order finite difference approximations and each of the PDEs reduced to a system of n ordinary differential equations (ODEs), whose solution was computed by a suitable ODE solver. Both fixed and free-end boundary conditions were investigated.

3. Simulation

Having validated the simulation tool, two real cables were modeled, considering different types of external excitation: a stay cable from the Normandy Bridge (France) and the main suspension cable of the 25 de Abril Bridge (Portugal). Time series of longitudinal and transverse deflections along the cable length were then obtained, for a period of 0.5 s.

4. Assessment of Dispersive Behavior

For all simulations, and according to the methodology proposed in (Kishimoto et al. 1995), Morlet wavelet transforms were used to obtain time-frequency distributions of transverse deflections in two different sections along the cable. The maxima of these distributions indicate the arrival times of each frequency component. Therefore, since the distance between the two sections is given, propagation velocities were computed for all frequencies. Figure 1 represents the dispersion relation obtained for different simulations.

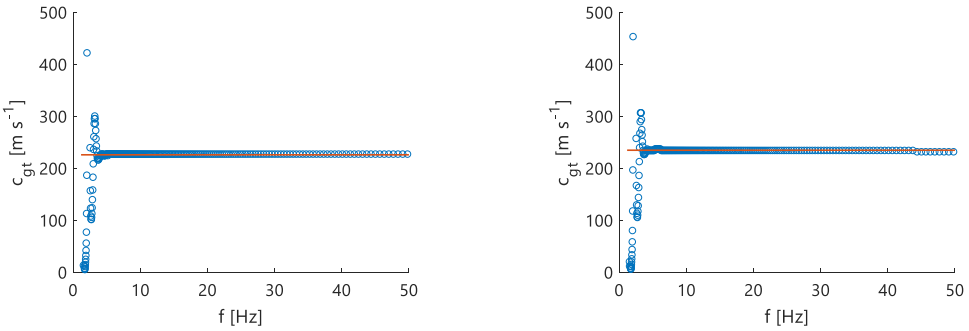

Figure 1: Dispersion relations for transverse group velocities at a stay of the Normandy Bridge (left) and the main suspension cable of 25 de Abril Bridge (right).

5. Conclusions

Numerical results are in good agreement with the analytical dispersion relations available in the literature, especially for high frequencies. The methodology presented in section 4 may support the experimental assessment of the installed axial force in bridge cables.

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An object-oriented Bayesian network model for maintenance system selection in structures

Sadegh lajevardi[1]

[1]Department of civil engineering, Faculty of engineering, Universidade do Minho, The campus of Azurem, 4800-058, Guimaraes, Portugal (Sadegh.lajevardi@gmail.com) ORCID 0000-0001-8405-8872

Abstract

Recent maintenance method development prepare many tools to manage project during operation. Meanwhile serious task to be made once a structure safe during operation is defined is the selection of maintenance method for various structure elements. To compare maintenance method with regard to decision criteria and the classified defect of structure's component, this paper presents an approach for decision making process in an object oriented model, in which each structure component is modeled with various possible alternative maintenance methods as an object. The uncertainty and defect probability combine with expert knowledge to find each maintenance method effects regarding the attributes of their component. This multi-criteria-decision-making deal with the essential imprecision of subjective judgment. To demonstrate the use and capability of the model, a case study is presented.

Author Keywords. Object oriented, Bayesian network, maintenance method, Risk assessment, Quality control

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Urban Development Policies and Instruments in Contexts of Financialization

Cláudia Affonso[1], Emília Malcata[2]
[1]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (a.claudiaaffonso@gmail.com)
[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (emalcata@fe.up.pt)

Abstract

This communication discusses the role of land value capture and large-scale urban development projects (UDPs) in promoting financialization processes. It also looks into how municipalities deal with these processes in order to further their agendas.

In urban planning, financializing policy instruments are those that, to finance the built environment, promote institutional arrangements that adapt to the needs of the property market, the financial market, and to their interdependencies and dynamics. These instruments reflect a political and sociotechnical evolution that fostered the conversion of property, as physical and tangible space, into 'quasi-financial' assets that commodify space. UDPs correspond to the stage where commodification of land occurs and financialization takes place; they are often funded through land value capture instruments which, in some cases, can both be financialized and prone to develop financialization processes. However, if municipalities are prepared to deal with these processes it's a question that needs further clarification.

Author Keywords. land value capture, large-scale urban development projects, financialization, financializing policy instruments.

Transportation, Sustainability and Mobility Justice

Isabel Cunha[1] , Cecília Silva[2]
[1] Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (isabelcunha@fe.up.com) ORCID 0000-0001-6566-9336
[2] Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ccsilva@fe.up.com) ORCID 0000-0003-2868-1840

Abstract
Changing the current mobility patterns by creating both public transport oriented and non-motorized development envisage a transition in the Transportation System's governance to achieve the expected sustainable and social performance. In this context, there are crucial gaps within the sustainable strategies and transportation planning which may perpetuate spatial and social inequalities in metropolitan areas. Thus, the present research presents a critical framework to assess to what extent the bicycle strategic planning can guarantee both accessibility and mobility justice in the sustainable mobility pathway.

Author Keywords. Sustainable mobility, Mobility justice, Equity, Bicycle, Metropolitan regions.

Type: Oral Communication
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1. Introduction

There is increasing multidisciplinary interest regarding the transportation systems pathway towards a low-carbon society. Cities are engaging a variety of approaches aiming to achieve an expected sustainable performance, targeting a competing range of economic, environmental and social objectives (Lyons 2018).

By definition, the transportation systems provide a range of infrastructures and services that enable people to travel through space, ascertaining the capability of a person to overcome spatial separation to experience diverse activities and opportunities provided by the city (Martens 2017). Thus, the low-carbon paradigm encompasses not only innovative policy-making process and planning instruments towards the promotion of sustainable and alternative modalities, but also deals with a range of crucial factors in terms of technology, infrastructure, knowledge, markets and user practices, cultural and symbolic meanings, policy and institutions, and the industries involved in production and operation (Docherty, G e J 2018) (Lyons e Davidson 2016) (Temenos, et al. 2017) .

Since sustainable mobility is highlighted in the urban agenda, urban planners, local practitioners and politicians are struggling to define planning guidelines to provide convenient, affordable and accessible transportation options with minimal impact on the environment and others. Despite the importance of local public transport, cycle and walking, the car dependence and increased decentralization of cities have been proven to be a complex process to reverse (Lyons 2018) (Pagliarin 2018). Furthermore, previous researches underlined critical evidence the transportation system's negative externalities continue to grow, and accessibility level in the transportation system is unevenly distributed (Pereira, Schwanen e Banister 2017) (S, et al. 2018) (Aaron Golub 2016) (Martens 2017).

A range of studies has drawn attention on how to make the transition to more sustainable systems of mobility and transport (M. Sheller 2015) (Golub e Martens 2014), as well as how to ensure social equity and justice into transport planning (Manaugh, Badami e El-Geneidy 2015) (Oswald e Mohammed 2016) (Bocarejo 2012). However, acknowledging the importance of access and bearing in mind different countries and cities have distinct starting points in terms of transport systems, governance, planning strategies and culture, there is a need to further understand the sustainable mobility pathway in a broader framework, and assess the main implications in terms of spatial dynamics and mobility justice.

The present PhD Thesis asserts the dominant culture of the car and the emergence of sustainable modes are rooted in a deep context of physical, social and symbolic values and constraints. Although there is some evidence of an increasing cultural shift towards active mobility worldwide (M. Sheller 2015) (Banister e Marshall 2000) (Banister 2008) (Sheller e Urry 2006), cycling and walking have intrinsic preconditions, being not accessible or performed for many social strata (Winters 2011) (Dill e McNeil 2013) (Dill 2009) (Gatersleben and Appleton 2007). Particularly focusing on the equity between access by automobiles and bicycle, the latter might be less democratic since many users have been classified into particular and biased groups as “white cyclists”, “sportive man”, “young people” (Aaron Golub 2016) (Lubitow e Mahmoudi 2017) (Stehlin 2015).

In this context, the present research hypothesis there are crucial gaps within the Transportation Planning and Sustainable Strategies, which may foster such exclusionary phenomenon. There is a need to explore to what extent the sustainable modes can guarantee spatial and social justice, in such paradigm change.

Thus, some questions emerged framed within this hypothesis: (1) How bridge the gap between Planning and Practice in order to guarantee equity and justice in the sustainable mobility pathway? (2) In what degree cities have been advancing civil rights as mobility justice, equity and inclusion within the sustainable mobility approach?

This research aims to provide a critical framework, assessing the main constraints and potentialities within the sustainable mobility development in selected metropolitan regions, contributing not only with the current debate in the academia but also bringing new insights into the transport planning strategies and practices.

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The Potential of Bike Sharing in Increasing Sustainable Mobility in Cities

João Filipe Teixeira[1], Cecília Silva[2], Frederico Moura e Sá[3]

[1]Research Centre for Territory, Transports and Environment (CITTA), Faculty of Engineering of the University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ega11021@fe.up.pt) ORCID 0000-0002-0948-9389

[2]Research Centre for Territory, Transports and Environment (CITTA), Faculty of Engineering of the University of Porto, (ccsilva@fe.up.pt) ORCID 0000-0003-2868-1840

[3]Centre for Studies in Governance, Competitiveness and Public Policies (GOVCOPP), University of Aveiro, (fredericomsa@ua.pt) ORCID 0000-0003-3660-2751

Abstract

In the last years, there has been a growing importance of cycling in the political arena, namely through the implementation of bike sharing systems (BSS). However, the role of BSS as a sustainable urban transport remains unclear, with an overall lack of research assessments and limited evidence on its ability to effectively induce modal shift from car to cycling.

This research objectives are twofold. First, to develop a methodology to assess car modal shifts due to BSS, considering direct modal shift to bicycle, either to bike sharing itself or indirectly to private bikes by normalizing cycling use; and to public transport, attracting new users by increasing its catchment areas and/or alleviating overcrowding. Second, to study causal relationships between the potential BSS advantages over car and its influence on inducing modal shifts. Consequently, this research should help at clarify the BSS ability in effectively reducing car use.

Author Keywords. Bike Sharing; Sustainable Mobility; Modal Shift

Type: Oral Communication

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One of the most popular policies promoting cycling as an alternative to car use is the implementation of bike sharing systems (BSS). BSS consist on the short term renting of bikes enabling low cost point-to-point trips (Ricci, 2015) and have achieved a significant growth in the past decade manly in Europe, North America and China (Shaheen & Zhang, 2010; Midgley, 2011; Fishman, 2015; Ricci, 2015).

There are several reported benefits attributed to BSS like reduced congestion and CO_2 emissions by decreasing motorized traffic, public health improvements by increasing physical activity, increased mobility options, increased accessibility, normalization and promotion of cycling, complement to public transport, travel time reductions, social equity, etc. (DeMaio, 2009; Shaheen & Zhang, 2010; Midgley, 2011; Gauthier, et al., 2013; Fishman, et al., 2013; Fishman, 2015; Ricci, 2015). However, there is a lack of research assessments and limited evidence on these benefits (Shaheen & Zhang, 2010; Fishman, et al., 2013; Fishman, 2015; Chardon, et al., 2017). For instance, the publicized estimates on CO_2 reductions are often overly optimistic as the existent analyses suggest that only a small share of car trips are replaced, with most of the substituted trips being from walking and public transport (Fishman, et al., 2013; Fishman, 2015; Ricci, 2015; Chardon, et al., 2017). In fact, multiple studies assessing modal shift showed modest results regarding car substitution, ranging from 2% in London to 21% in Brisbane (Fuller, et al., 2013; Fishman, et al., 2014; Shaheen, et al., 2014; Murphy & Usher, 2015). Notwithstanding the limited evidence on effective modal shift from car among bike sharing users, BSS present some potential advantages against cars. Firstly, within congested urban cores and to trips less than 5 km, cycling can be faster than driving (Dekoster & Schollaert, 1999). Evidence from Lyon's BSS points in that direction with 68.2% of the system's trips being shorter than car trips when there is a shortcut available, and cyclists

reaching average speeds of 14.5 km/h, close to the average car speeds in European urban cores (Jensen, et al., 2010). This advantage combined with most of BSS's users naming convenience as their key motivation for using bike sharing (Fishman, et al., 2013), provides an argument that BSS could potentially induce modal shift from car. Moreover, there is also potential synergy gains by combining BSS with public transport (Martin & Shaheen, 2014; Ma, et al., 2015). Martin & Shaheen (2014), through assessing survey data from the BSS of Washington DC and Minneapolis, argue that bike sharing can increase catchment areas in zones with less intensive public transport networks, as well as alleviate congested public transport systems in high density areas. Therefore, BSS can potentially induce modal shifts from car in two fronts:

1. By directly substituting car trips by cycling trips in short distances, and besides bike sharing trips, the BSS could also induce shifts to private bikes through normalizing cycling use (Goodman, et al., 2014);
2. By complementing Public Transport networks, either by acting as a first and last mile connector or by alleviating congested systems, potentially attracting new users.

This research aims at providing new insights about the potential of BSS to induce modal shift from car use.

Firstly, it will build a methodology to assess modal shifts due to BSS, mapping modal shifts from car within 4 possibilities (**Figure 1**). The direct modal shifts to BSS, which can occur either by BSS substituting short trips or by complementing Public Transport, will be obtained directly from the system by users' surveys and OD data. The indirect modal shifts, specifically car to private bike (due to normalization of cycling use in the city) and to Public Transport (due to alleviating overcrowding), will be estimated by a combination of existing city-wide travel survey data and proxies such as cyclist counting (Nordback, et al., 2013), Public Transport patronage (Ma, et al., 2015) and crowding levels (TfL, 2018) data.

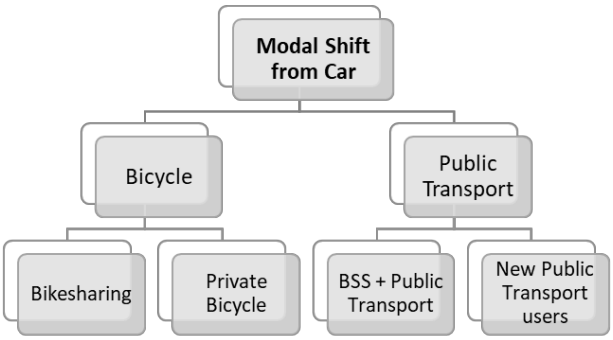

Figure 1: Possible modal shifts from car due to the bike sharing system's influence.

The second phase will consist on studying the causes leading to the observed modal shifts. As such, we will hypothesize assumptions that could lead to modal shifts, namely the bike sharing's convenience (translated in reduction of travel times), its ability in increasing the Public Transport catchment areas, as well as the perceived lifestyle benefits such as green intentions and health gains (Nikitas, et al., 2015). We will then explore causal relationships between the modal shifts and these assumptions using regression models.

Overall, this research should contribute with new insights about the potential of BSS in inducing modal shift from car and methodological approaches to assess it, as well as the identification of characteristics that can potentiate that modal shift, therefore, helping to clarify the role of BSS on sustainable urban mobility.

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Air-water influence in the pressure signal during pipe filling

João Paulo Ferreira[1], Dídia Covas[2]
[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (joao.cavaleiro.ferreira@tecnico.ulisboa.pt)
[2]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt)

Abstract
This study presents a comparison between pipe fast filling with and without entrapped air. Experimental data are collected from a copper pipe coil with high-frequency pressure transducers to evaluate pressures during the filling phase until full pressurization. A steep pressure increased is observed near the storage tank that fills the systems and at the copper pipe mid-length. A progressive increase of the air pressure inside the copper pipe is observed until the moment that the flow reaches the pressure transducer. Pressure variations are collected due to air-water behaviour; these data will be further used to calibrate a numerical model.

Author Keywords: Pipe filling, experimental analysis, air-water behaviour

Type: Oral Communication
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1. Introduction

Fast pipe fillings are known to cause massive pressure variations in pipelines (Marchis *et al.*, 2010), up to the point to be considered one of the main causes of pipe failure. This is increased when these fillings are recurrent and, also, in cases where air remains entrapped during the filling process. One of the main solutions for fast pipe fillings is the slow filling combined with appropriate air purge (Lauchlan *et al.*, 2005). Collected experimental data herein are intended to be used for numerical model calibration and validation going from 1D Method of Characteristics to CFD models.

2. Materials and Methods

An experimental facility assembled at the Laboratory of Hydraulic Resources at Instituto Superior Técnico, Lisboa is used for data collection. The pipe system has a coiled-type configuration, with a radius of 0.45 m and a height of 1 m and a total pipe length of 105 m. The copper pipe has an inner diameter of 20 mm and a wall thickness of 1 mm (Brito *et al.*, 2017). The system is composed of an upstream storage tank with 125 L of capacity, a centrifugal pump with a rated flow rate of 1 m^3/h and a rated head of 32 m, a 60 L stainless steel hydropneumatic vessel, the copper pipe and a full-port ball valve at the end for flow rate control. The hydropneumatic vessel, located at immediately downstream the pump allows a steadier head for the pipe filling, instead of direct supply from the pump.

Pressure measurements are carried out with pressure transducers at an acquisition frequency of 200 Hz at points T1 (at downstream the vessel) and T2 (at mid-pipe length). To simulate pipe filling conditions in a pipe network with redundancy, a short polymeric hose with an inner diameter of 0.0175 m is connected between points T1 and the control valve. This creates an air pocket inside the pipe, during the filling process, resulting in the air contractions and expansions until being completely taken by the flow. These air contractions and expansions

originate variations in the pressure signal. As the air pocket is contained between two waterfronts, the amount of air could not be measured at the exit at this stage. Each of the tests was carried out five times to ensure the phenomena repeatability.

3. Discussion

Collected piezometric-head data during the pipe filling with air entrapment are depicted in **Figure 1**. The valve from the hydropneumatic vessel is opened at time t = 10 s and the copper pipe starts to be filled two-way. The entrapped air pocket does collapse due to its near-linear pressure increase until the filling wave passes by the pressure transducer at pipe mid-length (Zhou *et al.*, 2013), around t = 16 s. The pressure increases near the hydropneumatic vessel until t = 20 s; from this moment onwards, the pipe friction component increases and the flow rate starts to get steady.

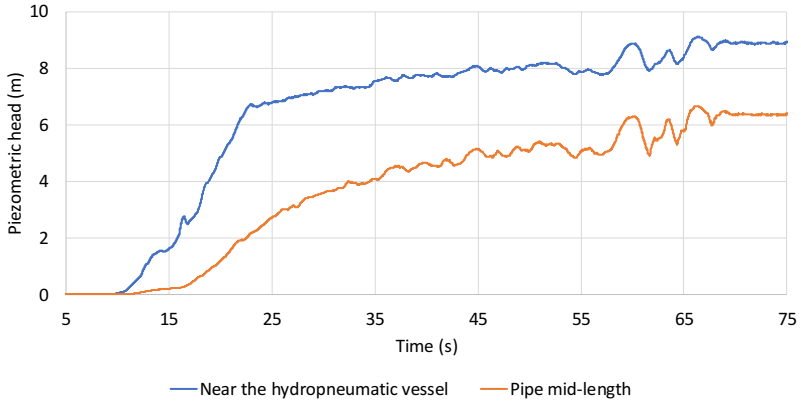

Figure 1: Gauge pressure measurements, for fast filling with air entrapment, near the hydropneumatic vessel and at copper pipe mid-length

4. Conclusions

The existence of air pockets delays pipeline filling with water and create high-pressure variations during this process. These pressure variations, when not controlled, can exceed the maximum pressures that the pipe can sustain, potentially leading to severe damages in pipe systems. In water distribution systems, particularly with intermittent flow, this issue becomes of the utmost importance not only due to the frequency of the filling processes but also due to the higher entrapped air volume and to the higher filling velocities.

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Operational Management of Hydraulic Infrastructures. Application of a methodology to the Case Study of the Wastewater Drainage System of Trofa

Jorge Cardoso-Gonçalves[1], José Tentúgal-Valente[2]
[1]MSc in Civil Engineering / PhD Student, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jjtc.goncalves@gmail.com)
[2]PhD in Civil Engineering / Associate Professor, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (tentugal.valente@adp.pt)

Abstract

Water management is faced with uncertainties and risks at different levels, having to meet the needs of society through resilient solutions (economically viable, environmentally sustainable, socially responsible) and consider the current challenges, namely: safeguarding of water sources; security of supply; preservation of the receiving means; sustainable development; response to extreme phenomena; adaptation of systems to new demands; management in scarcity scenarios. In accordance with a commitment to continuous improvement and with a dynamic transversal to the entire organization of the Management Entities, Operational Management of Hydraulic Infrastructures should be focused on increasing efficiency standards for operational optimization and for the search for robust and effective solutions.

The development of the Operational Management of Hydraulic Infrastructures methodology, referred to in this communication, is framed in a doctoral thesis in development (Author: Jorge Cardoso-Gonçalves[1]; Advisor: José Tentúgal-Valente[2]) and intends to systematize procedures of the exploration of water supply systems and of drainage of waste water, and to support decision making. The proposed methodology seeks to aggregate concepts of asset management, of risk management and of technical management, being organized into the following main components: Challenges; Organization; Operational Areas (Infrastructure Assessment, Exploration, Intervention).

Based on actual data of the exploitation of hydraulic infrastructures of the Trofa Wastewater Drainage System (SAR-Trofa), whose Management Entity is Águas do Norte, SA, the proposed methodology is tested and a Operational Management of Hydraulic Infrastructures strategy is designed for the reduction of operating costs, for the quality increasing of the provided service and for the safeguarding of environment. The study of the SAR-Trofa, from the point of view of infrastructure assessment, analysis and organization of exploration procedures, and systematization and proposal of interventions to be carried out, is performed with the objective to obtain practical results that support the operational management of these infrastructures, with particular focus on actions related to undue (rainfall and other) inflows.

Author Keywords. Operational management, wastewater, hydraulic infrastructures, undue inflows

Addressing challenges and uncertainties in asset valuation and infrastructure investment planning

Marta Cabral[1], Nuno Almeida[2], Jaime Gabriel Silva[3], Dália Loureiro[4], Dídia Covas[5]

[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (marta.f.cabral@tecnico.ulisboa.pt) ORCID 0000-0002-2734-8504
[2]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (nunomarquesalmeida@tecnico.ulisboa.pt) ORCID 0000-0001-7024-2679
[3]AdSA, Águas de Santo André, Cerca da Água Rua dos Cravos 7500-130 Vila Nova de Santo André, Portugal (g.silva@adp.pt)
[4]Urban Water Unit, National Civil Engineering Laboratory, Av. Do Brasil 101, 1700-066 Lisboa, Portugal (dloureiro@lnec.pt) ORCID 0000-0002-1169-7283
[5]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt) ORCID 0000-0001-6901-4767

Abstract
The current paper aims to discuss the main challenges and uncertainties associated to asset valuation and infrastructure investment planning. The methodology adopted to address these aspects is a three-step procedure: 1. Identification, characterization and site inspection of existing assets; 2. Estimation of the current replacement cost; and 3. Estimation of the current economic value. The application of this methodology implies dealing with numerous uncertainties, such as the calculation of the replacement cost, the choice of the degradation method and the selection and the correction of service lives according to assets' performance and physical condition. An industrial water supply system of the Industrial and Logistic Zone of Sines (ILZS) in Portugal is used as a real case study to highlight the complexity of asset valuation. Different competing investment alternatives were analyzed and assessed using a key performance indicator: the Infrastructure Value Index (IVI). Results include the IVI calculation for different assets using corrected service lives taking into consideration historical rehabilitation interventions and the estimation of future investment needs. IVI has proven to be a powerful tool to evaluate and to compare strategic investment alternatives, however, is of utmost importance to understand the underlying assumptions.

Author Keywords. Water supply system, asset valuation, investment planning.

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1. Introduction

This research presents the study of the main challenges and uncertainties associated to asset valuation and infrastructure investment planning. Valuations of water infrastructure assets are particularly challenging, especially due to the nature of these assets and the fact that they are rarely sold for which, generally, there are no market-based evidences of their fair value (Comisari *et al.* 2011). Asset valuation is important to establish investment priorities of infrastructures in the short-term and to analyze the different strategies of investment in order to maintain the service sustainable in the long-term. The infrastructure value index (IVI) is used to evaluate and to compare strategic investment alternatives. IVI is a measure that reflects the degree of youth, maturity or aging of an infrastructure. It is an appropriate measure to set targets for infrastructural sustainability criteria (Alegre *et al.* 2014). IVI is a widely used measure in the water sector; however this study intends to discuss the underlying assumptions through the use of a case study.

2. Methodology

The methodology for asset valuation is adapted from Cabral *et al.* (2019): 1. Identification, characterization and site inspection of existing assets; 2. Estimation of the current replacement cost; and 3. Estimation of the current value. Step 1 allow to have a better infrastructural knowledge and to evaluate the assets' condition. In Step 2, the replacement cost is estimated adopting established reference replacement cost in terms of unit costs. Linear regression models constructed for the different water infrastructures have been used (Covas *et al.* 2018). Step 3 includes the following stages: assignment of a useful life average technique to each asset, calculation of annual depreciation value, calculation the residual useful life as a function of the age, correction of residual useful life depending on the condition or incurred rehabilitation interventions and calculation of the current cost value of the asset.

3. Discussion

A case study of an industrial water supply system from the water utility *Águas de Santo André* (AdSA) is used to apply the methodology for asset valuation. The water supply system is composed of: intake pumping station; pressure tower; unburied gravity pipeline; channel with trapezoidal cross-section; tunnel; embankment dam with a pumping station; pipeline; water treatment plant; gravity flow pipeline and service tank.

Given the uncertainty associated to the service life of each asset, a sensitivity analysis of the system current value is carried out considering three scenarios of service lives: Scenario 1 – Services lives used in Australia; Scenario 2 – Service lives used in Portugal; Scenario 3 – Corrected services lives used in Portugal. Corrected services lives take into consideration the assets' condition and the rehabilitation interventions already carried out. Results are discussed in order to select the scenario that seems to better describe the reality of the analyzed water supply infrastructures in a fairer and more adequate way.

IVI is calculated for each asset and to study the different investment strategies in the long-term: Alternative 1 – Status quo (i.e., to maintain current operation and maintenance practices without rehabilitation interventions); Alternative 2 – Assets' replacement at the end of their service life; Alternative 3 – Maintain a constant IVI equal to 0.50.

4. Conclusions

One of the most important factors in planning and managing water systems is to maintain the water service sustainable, which implies to prioritize investments in short, medium and long-terms. Creating knowledge of the different uncertainties associated to the asset valuation and infrastructure investment planning, as well as of the respective implications and inherent errors, are essential steps in the management of water infrastructures.

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Modelling Flow Dynamics in Drinking Water Storage Tanks

Alexandre Pinheiro[1], Laura Monteiro[2], Maria do Céu Almeida[3], Dídia Covas[4]
[1]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (alexandre.pinheiro@tecnico.ulisboa.pt) ORCID 0000-0001-8956-3018
[2]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (laura.monteiro@tecnico.ulisboa.pt) ORCID 0000-0001-5232-2018
[3]Núcleo de Engenharia Sanitária, Laboratório Nacional de Engenharia Civil, Av. do Brasil 101, 1700-066 Lisboa, Portugal (mcalmeida@lnec.pt) ORCID 0000-0001-8488-2474
[4]CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (didia.covas@tecnico.ulisboa.pt) ORCID 0000-0001-6901-4767

Abstract
The research thesis in which this paper is included aims at understanding the effects of several governing factors on water mixing and on residence time distribution inside water storage tanks and identifying practicable solutions (infrastructural or operational) to improve the mixing performance and minimize the water aging. The research is being based on experimental tests carried out in laboratory small-scale tanks, specially assembled for this research. It includes velocity field measurement in laboratory experiments by using Particle Image Velocimetry (PIV). Advanced numerical modelling using Computational Fluid Dynamics (CFD) will be carried out to support the lab experiments.

Author Keywords. water storage tanks, flow dynamics, drinking water safety, numerical models, physical models

Type: Oral Communication
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1. Introduction

Water storage tanks are essential assets of a water supply system. They are usually designed to cope with the daily demand variation, assure the adequate pressures in the distribution networks and guarantee emergency water volumes (e.g., for firefighting). In addition, they are, generally, operated in order to maximize the system's reliability by storing the maximum volume of water during the night and to simultaneously minimize pumping costs when filled by pumping. Nevertheless, it is common to tank's design, operation and maintenance not guaranteeing the adequate mixing and renewal of the water inside. Often, storage tanks are potential sites of deterioration of drinking water quality and safety. These circumstances lead to the formation of stagnation zones with high residence times (Clark et al. 1996), (Grayman et al. 2004) which, in turn, lead to the extinction of residual disinfectant, usually chlorine, with the increase of disinfectant by-products (DBPs) formation. Excessive residence times can lead to the development of biofilms and the accumulation of sediments inside the tanks (Clifford et al. 2016). In addition, due to temperature differences between the stored water and the inflowing, vertical thermal stratification is also observed, affecting both the rates of the reactions as well as mixing of water layers of different density (Fisher et al. 2009). Consequently, the quality of the water in the distribution system can be significantly compromised, resulting in serious public health threats (U.S. Environmental Protection Agency 2002), frequent supply disruptions for tanks' cleaning and disinfection, and higher operational and maintenance costs, including additionally re-chlorination (Prasad, Walters, and Savic 2004), (Chambers, Creasey, and Forbes 2004).

2. Objectives and methodology

The current paper aims to discuss the main challenges and uncertainties associated to water mixing and on residence time distribution inside the water storage tanks and identifying practicable solutions (infrastructural or operational) for water mixing improvement and water aging minimization. The methodology is based on experimental research, as well as on mathematical modelling using advanced CFD. The experimental tests are being carried out in the Laboratory of Hydraulics and Environment of IST, where a small-scale facility with two tanks geometries (rectangular and cylindrical) have been assembled specially for this research. Dimensions of the tanks were determined by downscaling predominant geometries and configurations of existing full scale in Portugal. This facility is sufficiently flexible to allow the testing of several tank configurations and operation conditions relating to residence time distribution (RTD) function and water mixing. The experimental tests consist of the injection of a conservative compound and its monitoring at selected locations. This will allow to calculate the time it takes for the compound to travel from the injection point to the monitoring point. By comparing the point's values, it will be possible to infer on the mixing regime and to calculate the residence time distribution. Particle Image Velocimetry (PIV) will be tested to obtain velocity field measurements. Numerical models using CFD codes will be carried out to support the lab-scale tanks analysis and used for studying other tank's configurations and operational conditions not tested in the laboratory.

3. Conclusions

Water storage tanks can provide multiple benefits for the operation of water supply systems, as well as they can also be the source of multiple issues. Ideally, tanks should be fully mixed, but in practice this is rarely the case and there will be pockets of water which are not well mixed with stagnated zones where the water age can be considerably higher than the average age of water in the tank. Understanding the effects of several governing factors on water mixing and on residence time distribution inside the storage tanks and identifying effective single/combined measures (infrastructural or operational) for water mixing improvement is a step forward to avoid water stagnation, water quality deterioration and to guarantee water safety in distribution systems.

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Efficiency Assessment of Water Supply Systems in Mato-Grosso, Brazil, through a Benchmarking analysis: is there any real efficiency?

Marco Tourinho[1,2], Paulo Rosa-Santos[1,3], Francisco Taveira-Pinto[1,3]
[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal
[2]Secretaria de Desenvolvimento da Infraestrutura, Ministério da Economia, Bloco K, BRASÍLIA, Brasil
[3]ICIIMAR, Centro Interdisciplinar de Investigação Marinha e Ambiental da Universidade do Porto, Terminal de Cruzeiros de Leixões, Avenida General Norton de Matos, S/N, 4450-208, MATOSINHOS, Portugal
eng.tourinho@gmail.com (ORCID 0000-0002-5004-535X), pjrsantos@fe.up.pt (ORCID 0000-0002-3768-3314), fpinto@fe.up.pt (ORCID 0000-0003-4337-8428)

Abstract

Efficiency assessment (or benchmarking) have shown to be appropriate tools to simulate a competitive scenario in the water supply sector (Ananda, 2019; Pawsey *et al.*, 2018). In this sector, which has inherent monopolistic characteristics, the appropriate use of these tools stimulates the users' perception of systems and services and enables the construction of a balanced regulatory environment in which users have access to the operational information of the management entities that provides the water supply services.

However, a clear problem in the development of benchmarking is the definition of the management entity that will be considered as a reference for the others (the benchmark), namely in relation to the characteristics that define it as efficient. The use of information that has inherent inaccuracies is an obstacle to obtaining good results (Cabrera *et al.*, 2018). Moreover, the application of benchmarking methods, without taking into account the specifics of the systems (although with reliable data), and without realizing that there are many elements that influence them, can lead to inaccurate results.

A preliminary analysis of water supply services in municipalities of the state of Mato Grosso, Brazil, indicates that the application of the Data Envelopment Analysis (DEA) methodology, without observing the characteristics of the systems, can result in the definition of a service as efficient, even if the system has several major deficiencies that may not be perceived by the inputs or the outputs.

Author Keywords. Efficiency Assessment, Water Utility Performance, Benchmarking.

Type: Oral Communcation
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1. Introduction

Performance and efficiency assessment, commonly designated as benchmarking, refers to a strategy initially developed in the business sector, used to compare the relative efficiency of one entity over another, with similar characteristics or dimensions.

Benchmarking essentially consists of the application of comparative and quantitative methods of evaluating and measuring the performance of operators over time (metric benchmarking), which allow the regulator an ablative behavior of results that are included in the decision making process of the regulatory process. The advantages of employing benchmarking in water supply systems (WSS) are so

significant that in some countries the aggregation of managing bodies is prohibited (*e.g.*, in the UK by Ofwat) to maintain a sufficiently large number of entities to allow benchmarking exercises, even if it involves loss of possible efficiency gains due to the increase in scale and range efficiencies (Marques, 2011).

A major issue in the development of benchmarking, particularly in the Data Envelopment Analysis - DEA (due to its sensibility to the data) is the definition of the entity that will be considered as the benchmark (the reference) for the others, particularly in relation to the characteristics that defines it as efficient. The use of information that has inherent inaccuracies is an obstacle to obtaining good results (Cabrera *et al*., 2018). Moreover, the application of benchmarking methods, without taking into account the specifics of the systems (even with reliable data), and without realizing that there are elements that influence them, can lead to inaccurate results.

2. Materials and Methods

To estimate the efficiency scores and their determinants in the Mato Grosso water industry, the DEA method was adopted. This method has been widely applied to evaluate the efficiency of water utilities (*e.g.*, Cabrera *et al*., 2018; See, 2015) and consists of a non-parametric technique based on linear programming that allows for the construction of the efficient production frontier based on the inputs and outputs of the Decision Making Units (DMUs) (Charnes *et al*., 1978). The relative efficiency of each unit is calculated by comparing its inputs and outputs in relation to the rest of the units. Cooper et al. (2007) provide additional details on the DEA methodology. DEA models can either take an input or output orientation. In the framework of water industry, previous studies (*e.g.*, Molinos-Senante and Sala-Garrido, 2016; Guerrini *et al.,* 2015) have adopted input orientation since the aim of the WSSs is to provide water services minimizing the use of inputs. Considering this background, the present study adopts the input-orientated DEA model. In this case, given $j = 1{,}2 \dots, N$ units (WSSs in this case study), each one using a vector of M inputs - $x_j = \left(x_{1j}, x_{2j}, \dots, x_{Mj}\right)$ to produce a vector of S outputs - $y_j = \left(y_{1j}, y_{2j}, \dots, y_{Sj}\right)$, the input-oriented DEA model is denoted as follows:

$$Min\ \theta j \tag{1}$$

subjected to

$$\begin{aligned} \textstyle\sum_{j=1}^{N} \lambda_j x_{ij} &\le \theta x_{i0} && 1 \le i \le M \\ \textstyle\sum_{j=1}^{N} \lambda_j y_{rj} &\ge y_{r0} && 1 \le r \le S \\ \lambda_j &\ge 0 && 1 \le j \le N \end{aligned} \tag{2}$$

where θj represents the efficiency of the unit evaluated (being efficient when $\theta j = 1$ and inefficient whenever $\theta j < 1$), M the number of inputs used, S the number of outputs generated, N the number of units analyzed and λ_j a set of intensity variables which represent the weighting of each analyzed WSS j in the composition of the efficient frontier.

The selection of inputs and outputs is essential in DEA studies. In a literature review recently conducted by See (2015), it was evidenced that the input and output variables included in the efficiency assessment of water utilities vary notably in empirical studies. Regarding inputs, the most widely used variables include operating costs (Byrnes *et al.,* 2010), network length (De Witte and Marques, 2010), number of employees, total capital expenditure, etc. From the literature review, the most widely used output variables are the volume of water delivered (Guerrini *et al*., 2013) and the number of properties connected (Ananda, 2014). In this study, the two inputs considered were the operating expenditure (OPEX, in R$/year) and the network length (in km) and, for the output, the volume of water produced (1.000 m³/year) and the water supply coverage (%). As the DMUs, this study adopts the municipalities (*i.e.*, its systems) that exclusively provide water supply services.

3. Discussion

The DEA was carried out with the Win4DEAP2 software (Coelli, 1996). Figure 1 shows the relative efficiency in the 76 municipalities analyzed from Mato Grosso, Brazil.

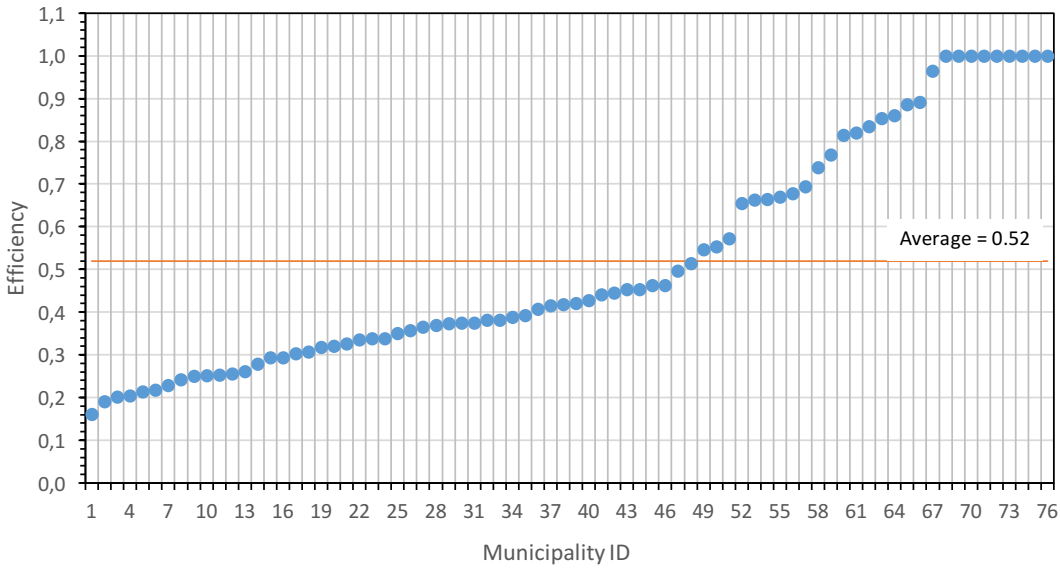

Figure 1: Technical efficiency of 76 Mato Grosso WSS.

The most efficient DMUs analyzed, along its inputs and outputs (*i.e.*, $\theta = 1$) are shown in Table 1.

Municipality	DMU	θ	OPEX (R$/year)	Network lenght (km)	Volume of water produced (1,000m³/year)	Water supply coverage (%)
Alto Taquari	Dmu2	1.000	653,409.89	20.0	1,115.00	91%
Araguainha	Dmu5	1.000	120,876.47	6.0	131.40	100%
Denise	Dmu19	1.000	95,000.00	200.0	1,000.00	99%
Jaciara	Dmu30	1.000	2,472,977.14	300.0	3,810.24	100%
Nova Olímpia	Dmu45	1.000	1,103,181.29	90.0	3,608.95	100%
Novo Santo Antônio	Dmu49	1.000	28,000.00	0.6	38.80	5%
São José do Xingu	Dmu59	1.000	356,206.51	10.0	691.00	100%
Santa Cruz do Xingu	Dmu63	1.000	195,734.12	9.0	480.00	100%
Tabaporã	Dmu69	1.000	475,000.00	45.0	1,800.00	97%

Table 1: Most efficient municipalities WSS and its inputs and outputs values.

Table 1 shows that the municipality of Novo Santo Antônio was defined as efficient even with its 5% of water supply coverage. This result is due to the inputs adopted in the DEA, *i.e.*, Novo Santo Antônio has a reduced water supply coverage, yet it has an OPEX proportionally low. Therefore, in this case, DEA has interpreted it as an efficient unit. Moreover, since the efficient DMUs were established, it is interesting to characterize some of the municipalities with data from its sanitation plan, as it follows in Table 2.

Municipality of Denise
Information of the supply services: provided directly by the City Hall. The system is supplied exclusively by an underground source, through 9 wells, 2 of which are equipped with meters. The treatment of water is carried out by simple disinfection by chlorine. Has three reservoirs, with a total storage volume of 290 m³ (considered insufficient to meet the consumption). The network is of the mixed type, with diameters varying between 50 and 160 mm in PVC, with approximately 80% of the network having a diameter of 50 mm. Has 95% coverage in water supply, with 80% monitored by meters. Water losses are estimated at 68.6% of the volume of water produced. The supply does not occur intermittently. Economic information: GDP per capita - R$ 46,645.93; Census population (2010) - 8,523; Estimated population (2018) - 9,377; Demographic density - 6.52 inhabitants/km²; Percentage of the population with income up to ½ minimum wage - 37.2%.
Municipality of Nova Olímpia
Information of the supply services: provided directly by the City Hall. The service is supplied exclusively by surface source. The treatment is carried out by a water treatment plant (WTP) considered to be in a precarious situation (with rusted and leaking elements). Has four reservoirs, with a total storage volume of 1,400 m³. Has 100% coverage in the supply. Water losses are estimated at 33%. Economic information: GDP per capita - R$ 32,212.24; Census population (2010) - 17,515 inhabitants; Estimated population (2018) - 20,034 inhabitants; Demographic density - 11.3 inhabitants/km²; Percentage of the population with income up to ½ minimum wage - 40.8%.
Municipality of Novo Santo Antônio
Information on water supply services: although there is a sector of the City Hall for administration of this type of service, the municipality of Novo Santo Antônio does not have a public water supply system, and currently the service is provided by artesian wells and shallow wells, without any quality control. Economic information: GDP per capita - R$ 14,481.12; Census population (2010) - 2,005 inhabitants; Estimated population (2018) - 2,574 inhabitants; Demographic density - 0.46 inhabitants/km²; Percentage of the population with income up to ½ minimum wage - 39.2%.

Table *2*: Municipalities characterization defined as efficient by the DEA analysis.

Table 2 shows a relevant aspect in the scope of the efficiency assessment: the municipality of Novo Santo Antônio presented a value of the technical efficiency considered high (it was considered as one of the benchmarks of the analysis), although the municipality does not have a full public service of water supply (considered as a complete system of supply networks and connections controlled and managed by an entity). Likewise, the Nova Olímpia municipality service was considered efficient, but it has very relevant deficiencies, namely in terms of its treatment plant. This result occurs because the benchmarking performed through the DEA did not take into account contextual information of the systems. As mentioned above, DEA considers efficient the decision units that proportionally has the "best" relations between output/input, regardless of their values, which means, for example, that a water supply service that has as an operating expense, the amount of R$ 100 thousand per year and 100% in the coverage of the service has the equivalent efficiency to a second service (from another municipality) that only has 20% in the service coverage, but has as an expense only R$ 20 thousand per year.

4. Conclusions

This study shows that both, variables (*i.e.*, information and indicators) and methods of analysis, have a significantly influence in the definition of the efficiency frontier. In addition, it became clear that a deeper analysis of the efficiency and performance methods is necessary, in particular the practical verification and analysis of the results to be obtained using the different methods.

The efficiency threshold defined based on the DEA methodology showed that the evaluation on this type of work should be done with great attention. It is important to collect the largest amount of contextual information in benchmarking exercises, so that inappropriate results are not achieve.

Results of previous studies show the efficiency assessment of water supply systems without detailing their characteristics. This study shows that a system can be define as efficient, in DEA methodology,

through a high quantity of outputs or a reduced amount of inputs. The result evidences that a double check has to be done to define the reference entity in a benchmarking exercise. In a benchmarking strategy, the reference entity (or the benchmark) must be not only the most efficient one, yet a high-level entity with the best service quality, which, occasionally would not be defined due regular efficiency assessment methodologies.

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Development of a novel wave energy converter based on the motion of multipurpose offshore floating platforms

Daniel Clemente[1], Paulo Rosa-Santos[2], Francisco Taveira-Pinto[3]
[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (ec10140@fe.up.pt) ORCID 0000-0003-4599-9287
[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (pjrsantos@fe.up.pt) ORCID 0000-0002-3768-3314
[3]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal; CIIMAR - Centro Interdisciplinar de Investigação Marinha e Ambiental (fpinto@fe.up.pt) ORCID 0000-0003-4337-8428

Abstract
As the world faces complex challenges such as climate change, growing energy demand and energy security, strengthening the existing energetic mix is vital to ensure the sustainability of modern and future generations. As such, a combination of various renewable energy sources (RES), such as hydropower, wind and solar, has been developed over the last decades to tackle these challenges and present viable alternatives to fossil fuel solutions. Lately, their increasing level of maturity has allowed RES to become commercially competitive and attain a relevant share of the global energy market, which is expected to increase further in the near future. Hence, not only have RES become attractive from a commercial perspective, but they also present an invaluable opportunity to ensure a sustainable and secure energy market.

Amongst the RES alternatives, marine renewable energy (MRE) has become one of the most promising sources, with an abundant theoretical resource and a higher power density than that of solar and wind, as well as greater predictability (Clément *et al*. 2002). MRE encompasses several variants, ranging from tidal to wave energy, each with different contributions to the overall theoretical resource. These have been benefitting from favorable supporting policies that have allowed for hundreds of different concepts to be studied and developed around the world. However, despite the high number of existing concepts, a definitive design consensus has yet to be reached, thus stopping the MRE sector from reaching a level of maturity alike its wind and solar counterparts. Moreover, the costs of developing, deploying and operating these devices remains high (Astariz *et al*. 2015) in comparison with other energy sources, making it difficult for MRE converters to reach a commercial stage.

One of the most pressing obstacles to the successful development of a MRE converter regards its operational stage. After being deployed, a converter is subjected to the harsh marine environment, with key components becoming susceptible to fatigue, excessive loads and corrosion. This leads to high operation and maintenance costs (O&M) and additional logistical challenges to be addressed during the concept's life cycle. To counter this drawback, several concepts have recently been developed with a design that promotes the protection and isolation of key electromechanical components from the surrounding marine environment. Such is the case of wave energy converters (WEC) like the WITT (Crowley *et al*. 2018) and the ISWEC (Bracco *et al.* 2011), amongst others. Their design and operational mode is simple, yet versatile, allowing them to be, in theory, adaptable and attractive options for the wave energy sector.

Under this scope, a novel WEC concept – designated as the E-Motions – is being developed since a few years ago. This device converts wave energy into electricity through wind and, mostly, wave induced oscillations of multipurpose floating platforms. This new concept can either be installed on existing platforms, such as vessels and ships, or incorporated into an optimized design aimed at incrementing the oscillatory response of the WEC. Analogous to the beforehand concepts, the E-Motions is capable of providing protection to the necessary equipment by sealing it within the hull of the floating platform. Furthermore, the operational principle is simple and the device can be adapted as to be integrated into various floating platforms for numerous applications.

Thus far, the E-Motions WEC has been subjected to an experimental proof-of-concept study (Clemente 2015) and a preliminary numerical assessment (Braga *et al*. 2018), with ANSYS® Aqwa™, from which initial results

regarding its energy production and behavior were attained. Presenting and discussing the latest stage of development of the E-Motions is the core purpose of this communication. In this respect, the simulations carried out, thus far, encompass different geometries of the floating platform component, as well as various Power Take-Off (PTO) damping and mass value. The numerically reproduced model of this WEC was studied under different wave conditions. The results corroborate the complex and non-linear nature of the PTO-floating platform interaction and yield new estimates on the energy output of the E-Motions. Moreover, a preliminary study regarding the introduction of E-Motions units into potential deployment sites is discussed. This study was carried out with the assistance of the SWAN/Delft3D third-generation software. Lastly, the potential introduction of a control system is addressed, through the application of the SimTwo numerical tool (Costa *et al*. 2011).

Author Keywords. Wave energy converter, Renewable marine energy, Optimization, Composite modelling.

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Scour development under different flow rates for sediment mixtures

Saeid Okhravi[1], Saeed Gohari[2], Rodrigo Maia[3]
[1]Ph.D. Candidate, Department of Water Engineering, College of Agriculture, Bu-Ali Sina University, Hamadan (65178-38695), Iran (s.okhravi94@basu.ac.ir)
[2]Assistant Professor, Department of Water Engineering, College of Agriculture, Bu-Ali Sina University, Hamadan (65178-38695), Iran (s.gohari@basu.ac.ir)
[3]Associate Professor, Departamento de Engenharia Civil, Faculdadede Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, s/n, Porto 4200-465, Portugal (rmaia@fe.up.pt)

Abstract
Bridge piers are often located in channel riverbeds formed by non-uniform sediment mixtures. However, the influence of bed sediment types on the scour process are not yet well understood. Therefore, a series of laboratory experiments were conducted in a channel for five different sediment beds under two steady flow discharges (20 and 35 l/s) around a single bridge pier model. Two of the sediment beds were composed of uniform sand and in the remaining three, the sediment was non-uniform. The results showed that in general the scour depth increases with the flow discharge increase. However, the rate of variation of erosion depth over time is very different for the various bed sediment types. For the same median sediment size and flow condition, the scour depth was found to decrease dramatically as the non-uniformity index increased, due to the development of an armor layer. Following the results, the impact of the median grain size of complex mixtures of sediment is also discussed.

Keywords. Armor layer, Flow conditions, Local scour depth, Non-uniform sediments

1. Introduction

Research on local scour has been primarily focused on investigating the impact of different hydrodynamic conditions on scour in a bed of uniformly graded material. Melville and Coleman (2000) provided comprehensive summaries on this research. Although local scour investigations in a bed of uniformly well-graded material could provide knowledge of the underlying processes, field sediment beds are much more complex consisting of non-uniform sediment mixtures ($\sigma_g > 1.4$). In the case of complex sediment beds, selective transport of the finer particles due to unequal mobility can make the bed surface to be armored (Orrú et al. 2016). There have been relatively few studies reported in the literature relating to scour in complex sediment beds, and most of those relate to quite specific situations (Dey et al. 2011). Furthermore, there are still significant gaps in knowledge of scour development in complex sediment beds. The aim of this study is to improve understanding of scour development and armoring evolution in non-uniform sediment beds for estimating the scour depth in more realistic field conditions.

2. Materials and Methods

The present experiments on local scour were conducted at the hydraulic laboratory of the Bu-Ali Sina University (Hamadan-Iran). The pier model with a diameter of 4 cm was put inside a 0.5 m wide, 10.5 m long and 0.5 m deep rectangular tilting flume. The test section was 3 meters long with the pier model positioned in the middle of the recess box. In this study, five types of sediment beds, composed both of uniform and non-uniform sediments, have been investigated in clear water local scour. The experiments were conducted under two steady flow discharges of 20 and 35 l/s to assess the degree of armoring (sediment coarseness of surface layer) in non-uniform sediments. The duration of tests was fixed at 8 hours in all runs.

3. Results and Discussion

The effect of non-uniform sediments on scour in a current clear water conditions showed that maximum scour depth was less than the scour depth in a uniform sand with the same d_{50} value. The comparison between the bed configuration 1 and 2 (C_1 and C_2 in table 1) showed that the change in geometric standard deviation (σ_g) from, respectively, 1.4 to 2 (by altering the uniform bed to non-uniform), decreased the maximum depth of scour by 70% and 60% in two corresponding experiments. Otherwise, there was not remarkable decrease on the scour depth by increasing non-uniformity index between C_3 and C_4, since the two corresponding sediment types were non-uniform (Table 1). Sui et al. (2010) reported similar results under clear water conditions around abutments. In general, scour depths for a given flow intensity decrease as σ_g increases. The reason for the reduction in scour depths is the presence of an armor layer on the approach bed and in the scour hole. Local maximum scour depth for a particular σ_g occurs at critical flow velocity (U_c). As each sediment corresponds to a unique value of U_c, which is dependent on the sediment size and grading, an increase of σ_g leads to a coarser armored bed and a correspondingly higher U_c.

Table 1: Summary of measured experimental data

Test ID	Bed configuration	Q (l/s)	dsm[2], (cm)	Time to obtain dsm (min)	Scour hole dimension (cm) (x×y)	Transported sediments[1] (kg)
C1-A	**C_1**- Uniform bed	20	6.1	420	32×26	2.2
C1-B	$□_{50} = 2$ □□, $□_□ = 1.4$	35	7.2	390	40×30	4.1
C2-A	**C_2**- Non-uniform bed	20	1.8	120	22×18	2.2
C2-B	$□_{50} = 2$ □□, $□_□ = 2$	35	2.9	300	28×20	5.3
C3-A	**C_3**- Non-uniform bed	20	3.8	390	28×18	10.8
C3-B	$□_{50} = 1$ □□, $□_□ = 2$	35	4.4	100	34×19	13.8
C4-A	**C_4**- Non-uniform bed	20	3.5	300	18×17	8.9
C4-B	$□_{50} = 1$ □□, $□_□ = 3$	35	4.3	270	26×18	11.1
C5-A	**C_5**- Uniform bed	20	3.1	240	14×12	0.01
C5-B	$□_{50} = 3.5$ □□, $□_□ = 1.4$	35	3.7	150	20×14	0.02

4. Conclusions

The results showed that scour depths decrease as σ_g increases for both beds with uniform and non-uniform sediments for the same d_{50} values. The reduction was due to the presence of an armor layer in the approach flow bed. Also, the experimental observations in any bed granular material revealed that with increasing flow rate, the armor layer became coarser, and larger scour depths were recorded. However, scour depth increase rate is very different for the various bed sediment types.

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[1] The weight of transported sediments at the end of test section
[2] The maximum depth of scour

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Empirical assessment of the co-development of rail and land in Tokyo

ABSTRACT

It is well-acknowledged the mutual relationship between transportation infrastructure and urban development. Transportation infrastructure stimulates urban development through providing better accessibilities, which then grant premium to estates within its reach, as well as fast-growing urban areas stimulates transportation development through increasing the demand for transportation and supporting further expansion.

The number of studies that succeeded to evidence that some cities, regions or neighbourhoods intentionally developed transport infrastructure prior to urban land through a historic approach outweighs the few other that had empirically assessed the order between both. Briefly, empirical studies use quantitative data and complex regression analysis techniques to asserts the classic 'chicken and the egg' question and thus establish an order between transport and urban development: Does urban development lead to the construction of new transport infrastructure to support it, or do new services on vacant-land induce new urban development?

Empirical studies have assessed the co-development of land and rail in New York and London. Both studies found a negative contemporaneous relationship between land use and rail development in the core whereas just London have found a positive contemporaneous relationship in the periphery. Nonetheless, the results found no lagged relationships between rail and land development in the periphery. The negative feedback in the core relates to the competing relationship between residential and commercial uses, a common pattern across most metropolis. On the other hand, the absence of a positive feedback in New York, especially in its periphery, is often related to the lack of interest of public transport companies on developing empty areas. The positive feedback in London may result from real estate ventures developed by some railway companies along services in the outskirts, like the Metropolitan Railway and its Metro Land.

Differently from western cities, most major and some minor private railways companies in Tokyo strategically developed real estate and other non-transport-related business to generate ridership in a very competitive market, notably in its periphery. This research proposes to empirically assess the existence of lagged relationships between land and rail development in Tokyo, a city where the co-development of rail and land is well documented.

The panel is structured in a 5-year interval according to the Japanese census, which ranges from 1920 with the last available record for the year 2010, providing a total of 19 regular intervals. Exception regards the year 1945, which due to the War was based on a survey and the proper census was delayed to the year 1947. Further spatial and time stratification were conducted to avoid the War break biasing and to capture differences between the core, the inner ring, and the periphery.

Several lag periods were tested, as well as combinations of one-period and two-period lags across unrestricted and restricted time-series stratification. Different lag-structures was found: 5-year interval in the core, 20 to 25-year interval in the inner ring, and 30 to 35-year interval in the periphery. The results find that surface rail network lagged population development in the inner ring and in the peripheral by 20 to 35-year, respectively. Contemporaneous effects were found: negative between population and underground rail in the core; and positive between population and surface rail in the periphery.

KEYWORDS: Transport, Land use, Tokyo, network growth, population growth

Identification and Analysis of Risk Factors related to Road Infrastructure to set Countermeasures

Mariane Paula Bobermin[1], Sara Ferreira[2]
[1]Faculdade de Engenharia, Universidade do Porto, Portugal (mariane.bobermin@fe.up.pt)
[2]Faculdade de Engenharia, Universidade do Porto, Portugal (sara@fe.up.pt) ORCID 0000-0001-7469-3186

Abstract

Despite the Decade of Action for Road Safety is coming to an end, and some improvements have been made in this period, the Sustainable Development Goals target 3.6 to halve road traffic deaths by 2020 will not be achieved, and efforts on road safety will continue to be a pillar to guide global actions into accident prevention for the next decade (World Health Organization 2018). One strategy that can be adopted towards road safety is the System Approach (Reason 1990) which considers that humans are fallible, and errors are expected to occur. Therefore, the objective is to understand the influence of different factors that contribute to the system fail (i.e. the accident).

Indeed, transport systems are heterogeneous, depending on driver population, road characteristics, weather conditions, traffic conditions, and road design standards. Hence, identification of the relationship between traffic accidents and the causative factors is a complex task, but it is the first step in the adoption of preventive measures to reduce the number and severity of traffic accidents.

One of those factors is the road infrastructure that drivers are exposed to. According to Papadimitriou et al. (2019), fifty-nine road risk factors associated to road infrastructure were identified under a review process to be potentially related to accident severity and frequency. Some of them were considered high risk level, whilst many of them demonstrated negative impact, but more studies are still required to determine the extension of their influence.

In this context, this study aims to identify the main characteristics of the road infrastructure of single lane highways associated to traffic accidents in the Brazilian federal road network. Firstly, data from accidents (police reports) will be assigned to road infrastructure, creating a dataset with both characteristics. Secondly, an exploratory analysis of this dataset will be conducted using a clustering method in order to identify groups in which specific road infrastructure characteristics are associated to accident severity and/or frequency. Former researches on traffic accidents (Depaire, Wets, and Vanhoof 2008) advise the application of a classification technique before a further analysis of each group and its specific characteristics.

The exploratory analysis will guide the selection of the road infrastructure characteristics to be investigated mainly in terms of driver behaviour influence, in order to understand the situations that eventually lead to accidents. Finally, and based on the mentioned selection, scenarios will be set and implemented in a virtual environment to perform a driving simulator experiment to directly access driver interaction with road infrastructure characteristics and with countermeasures designed to improve road safety.

Author Keywords: traffic accidents, road safety, road infrastructure, clustering analysis, driving simulator.

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Uncovering university student's commuting patterns

Catarina Cadima [a], Cecília Silva [b] , Paulo Pinho [c]

CITTA - Research Centre for Territory, Transports and Environment
Faculty of Engineering of the University of Porto
(Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal)

[a] catarina.cadima@fe.up.pt, ORCID 0000-0002-4969-5013
[b] ccsilva@fe.up.pt, ORCID 0000-0003-2868-1840
[c] pcpinho@fe.up.pt, ORCID 0000-0001-5159-8856

Abstract

Commuting patterns generate environmental impacts which study has been attracting the interest of scientists and authorities on the search for environment-friendly alternatives. While general awareness of sustainability issues has improved through mass media coverage, the corresponding knowledge is not always translated into actual sustainable practice in universities. University students are considered a dynamic group. having a significant impact on local housing markets. Yet, students are temporary residents with little power and often invisible to policy design. Nevertheless, their daily commuting to campus may generate adverse impacts, like traffic congestion and parking pressure on surrounding areas and on the performance of the local transport system.

Our purpose is to explore how commuting patterns of university students have changed over the last decade identifying if they are becoming more sustainable. In order to obtain a deeper understanding of travel behaviour of university students we combine (i) local spatial factors with (ii) personal factors in three different moments: 2006, 2012 and 2017. We used Geographic Information Systems (GIS) to collect data information on residential location and accessibility from each student (macro social information from Portuguese Census and document analysis - transport system) and we cross this information with data from personal surveys. In total, we collected 345, 352 and 430 responses in 2006, 2012 and 2017, respectively from a representative sample of the student population from the Faculty of Engineering of the University of Porto (FEUP). Multinomial logistic models were performed to accomplish our objectives. We used non-motorized-transport (NMT), public transport (PT), and the private car (PC) as outcomes.

Our findings reveal that FEUP students' commuting patterns have changed significantly. When we crossed data over time our results showed that (a) travel attitudes are gradually changing pointing to more sustainable behaviours (b) and students are increasing their accessibility conditions. Notwithstanding, our results also revealed the spatial analysis zones were most students still use the private car. Understanding the key factors underlying students' modal choices is crucial to assist university leaders in the development of their community engagement strategy to motivate their community members to take practical steps towards building a sustainable campus.

Author Keywords. Travel behaviour; modal choice; sustainable mobility; university students Oporto Metropolitan Area.

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The role of Urban Design in breaking car-oriented Mindsets

Ana Cláudia Proença[1], Cecília Silva[2], José Palma-Oliveira[3]

[1]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (anaclaudia@fe.up.pt) ORCID 0000-0002-0180-273X

[2]Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ccsilva@fe.up.pt) ORCID 0000-0003-2868-1840

[3] Faculdade de Psicologia, Universidade de Lisboa, Cidade Universitária, Alameda da Universidade, 1649-004 LISBOA, Portugal, (jpalma-oliveira@psicologia.ulisboa.pt) ORCID 0000-0001-9799-3464

Abstract

This paper follows the objective of defining the effects of urban design on the mobility mindset of the population, further exploring the car-oriented mindset that is prevalent in nowadays societies, where most streets are less friendly to pedestrians than they are to cars. By understanding the effects not only on the mobility behaviour, but also on the attitudes, opinions, values and beliefs that guide that behaviour, the municipality's mobility strategy can be better tailored, contributing to urban planning enrichment towards sustainable cities.

In order to achieve this goal, case-studies in neighbourhoods with particular characteristics will selected and evaluated by gathering quantitative data with surveys and qualitative data after street intervention with interviews. The data collected between communities of different types of urban designs and in the same population before and after intervention will shed light on the interaction between built environment and human mindset towards mobility.

Author Keywords. Urban Design, Mobility Mindset, Mobility Behaviour, Place Attachment.

Type: Oral Communication

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1. Introduction

After the World Wars, cities around the world were increasingly planned and developed to accommodate road traffic and related mobility patterns by fomenting the required urban infrastructure, contributing to issues like traffic congestion, air and noise pollution and resulting climate change and health problems to rise (Pinho e Silva 2015). These concerns sparked renewed interest to explore the link between mobility and urban form since designing neighbourhoods, cities and regions in a way that can reduce private car dependency, promote healthier, more sustainable urban forms and a variety of travel solutions, making the city more accessible to all (UN-Habitat 2014).

The built environment's impact on travel behaviour is one of the most studied relations in travel behaviour research, allowing the main influencing characteristics to be identified. The first three Ds of the built environment, initially proposed by Cervero and Kockelman, were Density, Diversity and Design (Cervero e Kockelman 1997), updated later with Destination accessibility and Distance to transit (Ewing e Cervero 2001). Demand management, including parking supply and cost, is considered the sixth D in several studies, while the seventh D, although not directly related to the environment, is sometimes considered Demographics (Ewing e Cervero 2010). According to Ewing and Cervero, traditional neighbourhoods have considerably greater shares of walking, bicycling, and transit use than contemporary neighbourhoods (Ewing e Cervero 2001). The study of neighbourhoods is particularly

important since there is evidence that residential built environment characteristics are more influential on commute behaviour than the built environment characteristics at job locations (Sun, Ermagun e Dan 2017).

Even if we consider that there is a tendency for people to choose the location of their residence according to their modal preferences (Munshi 2016, Lindelöw, Svensson e Brundell-Freij, et al. 2017), it is necessary for the built environment to increase travel satisfaction of sustainable mobility choices (Ye e Titheridge 2017). While improving public transportation is a great strategy to counteract car dependency and dominance (Ding, et al. 2017), urban planning must first start on improving cyclability and walkability for short distance trips, making cycling and walking a visible and viable form of every day transport (Pooley, et al. 2014). Although some route-choice studies assume that pedestrians always choose the shortest route, many other studies have proven it is not that simple (Guo e Loo 2013). How a city is designed influences greatly how walkable it is, depending on the barrier and attractive factors it possesses, according to Ferrer et al. in their studies in Granada and Valencia (Ferrer, Ruiz e Mars 2015) (Ferrer e Ruiz 2018),. High density of pedestrian traffic signals with poor coordination, difficult topography, sidewalk unavailability and insecurity are some of the barriers encountered in literature, while the attractive factors are the presence of wide paths, low traffic volume roads (Rodríguez e Joo 2009), green areas (Sarkar, et al. 2015), that in turn increase comfort and pleasurability (Lindelöw, Svensson e Sternudd, et al. 2014, Rafiemanzelat, Emadi e Kamali 2017). Indeed, according to Jacobs, streets are not merely their spatial functions of access and movement, but symbolic, ceremonial, social, and political urban spaces (Jacobs 1993, Jung, et al. 2017). Psychosocial factors like value sets and beliefs, spatial perception (Steg, Berg e Groot 2012) and spatial identity to the neighbourhood (Bernardo e Palma-Oliveira 2012) can influence behaviour, since it interacts with the perceived environment (Deutsch, Yoon e Goulias 2013, Devine-Wright 2013, Ferreira, et al. 2016, Wang 2015). As such, walkable, mixed-use neighbourhoods have higher levels of social engagement compared to those living in car-oriented suburbs, improving social identity and place identity and consequent place attachment (Leyden 2003).

As demonstrated, the strategy for sustainable mobility must consider the human element and recognise the importance of the effects of creation of attitude and its translation into behaviour, otherwise even Transit-oriented development (TOD) strategies can have varied results in different cities and population, as Lund et al. discovered (Lund, Cervero e Willson 2004, McKibbin 2011).

2. Objectives and Methods

The main objective of this research is the definition of the effects of urban planning and, by consequence, urban design on the population's behaviour and mindset towards mobility, focusing in particular on the prevailing car-oriented mindset. The knowledge gathered throughout the pursuit of this objective will allow transport and land use planners to understand the psychosocial repercussions of their urban interventions in short and long term, therefore contributing to the 11th Sustainable Development Goal, that aims to make cities and human settlements inclusive, safe, resilient and sustainable, by finding effective urban designs that encourage more sustainable mobility habits by the population and a better quality of life, which in turn help achieve both the 13th and the 3rd Sustainable Development Goals that intent to combat climate change and its impacts and to ensure healthy lives and promote well-being.

This research goal is supported by the following sub-objectives:

1. Parallel study of the different types of urban design, focusing on car-oriented planning, and the study of related environmental psychology;
2. Study of neighbourhoods with different urban design by doing an environmental and psychosocial evaluation by survey and the study of the effect of interventions with interviews;
3. Proposal of principles and recommendations to conceive and design better public urban spaces to improve population's mobility sustainability, considering the effects on their habits and mindset, by balancing relative competitiveness of all transport modes.

The methodology of this research is divided in two stages: the first is the qualitative analysis through a door-to-door survey and the second is a qualitative analysis with a route mapping to be experienced by volunteers in an intervened neighbourhood and an interview.

The door-to-door survey will be applied to neighbourhoods with specific physical characteristics, e.g. network format (traditional, planned unit developments or hybrids), streetscape (road transport focused, pedestrian focused, with cycling infrastructure, or balanced) and access to public transport. The survey will contain three parts: the first part will be a travel diary to gather information about the basic mobility indicators and a question to draw the most used walking routes in their neighbourhood according to trip purpose, the second part will inquire about the respondent's perception of the neighbourhood and level of place attachment and the third part will have timed questions to assess their attitudes and overall mindset towards mobility.

In a recently intervened neighbourhood, volunteering residents will be selected according to their selected modal choice and invited to try a new route to their main destination and back through the intervened street. After the experience, they will be interviewed to evaluate the psychosocial effects of the variation of the urban design.

3. Discussion and Conclusions

Even though this research is still at its early stages, the triad between attitude, behaviour and environment appear to be the key concepts to better understand the dynamics of mobility and its impacts on urban planning. Considering mobility related behaviour, research has focused on individually, and most recently socially, reasoned behaviour. While the concept of "nudging" and the study of the influence of environmental psychology on choice are growing in importance, research still relies on the Theory of Planned Behaviour by Ajzen to predict transport behaviour (Ajzen 1991). These studies have generally concluded that the choice of travel mode is largely a reasoned decision related particularly to attitudes, social norms (both injunctive and descriptive) and perceived barriers to behaviour. All of these are influenced by our perception of the social and physical environment, which creates a social and a place identity (and associated place attachment).

Based on Ajzen's Theory of Planned Behaviour and the Ecosystem model of a neighbourhood by Barton, Grant and Guise, a new Person-Behaviour-Environment model was proposed (Figure 1) (Ajzen 1991, Barton, Grant e Guise 2006).

With this model in mind, this research aims to address the sustainable mobility issue by bringing light to the psychosocial and environmental influences that mould the mobility mindset.

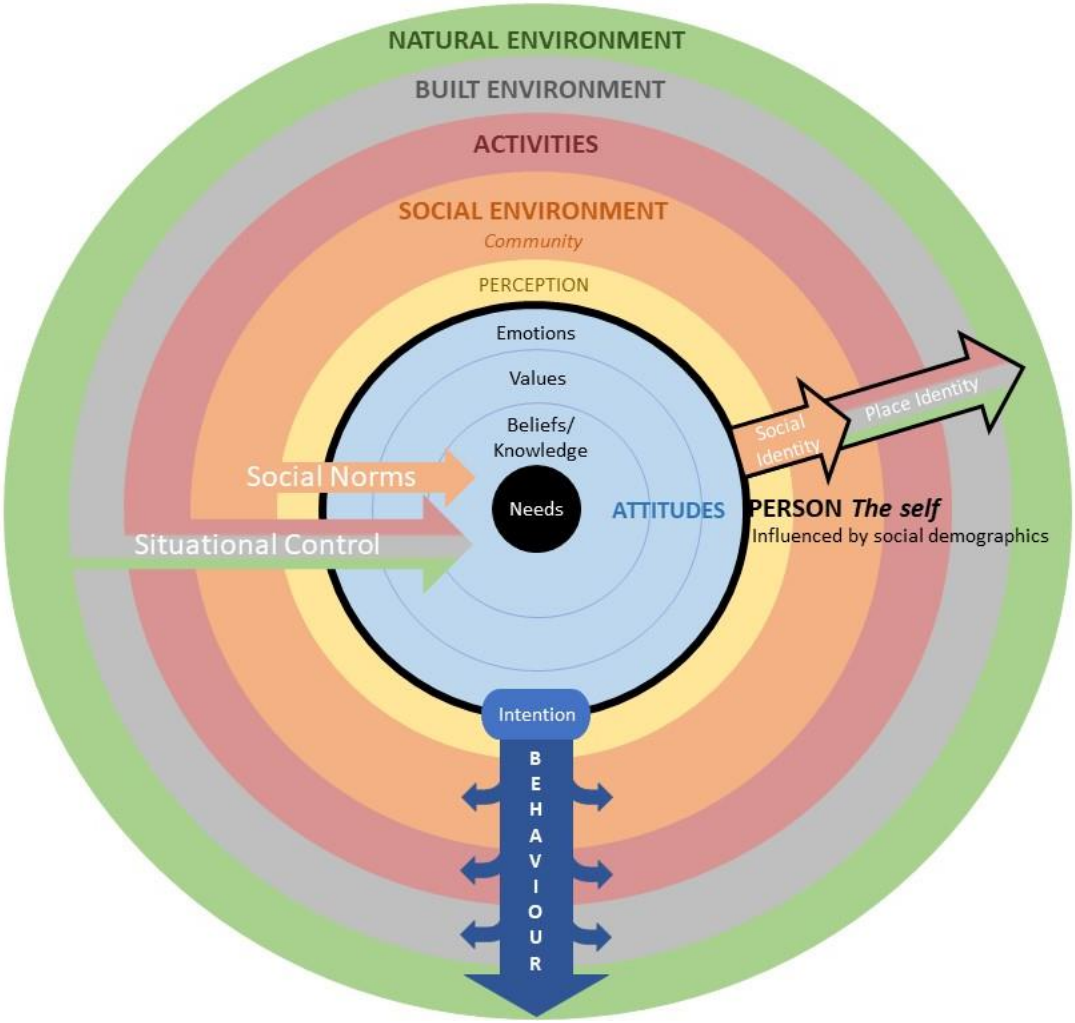

Figure 1: Proposed Ecosystem model of an individual and their interaction with the environment (Person-Behaviour-Environment).

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Seismic vulnerability assessment and retrofitting strategies for infilled RC frame buildings

André Furtado[1], Hugo Rodrigues[2], António Arêde[3], Humberto Varum[4]
[1]CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Portugal (afurtado@fe.up.pt)
[2]RISCO, Escola Superior de Gestão e Tecnologia, Instituto Politécnico de Leiria, Portugal (hugo.f.rodrigues@ipleiria.pt)
[3]CONSTRUCT-LESE, Faculdade de Engenharia da Universidade do Porto, Portugal, (aarede@fe.up.pt)
[4]CONSTRUCT-LESE, Faculdade de Engenharia da Universidade do Porto, Portugal, (hvarum@fe.up.pt)

Abstract
The out-of-plane (OOP) performance of infill masonry walls subjected to earthquakes is a topic of growing importance due to the significant number of collapses observed through the recent earthquakes. Nowadays is recognized by the scientific community the influence of these elements in the structural response of reinforced concrete structures subjected to seismic actions. The infills OOP behaviour depends on a series of variables and there is a lack of experimental data to understand and predict their expected seismic performance. There is a need of data to calibrate numerical models and to understand the effect of each variable such as type of masonry, boarder constrains, previous in-plane damage and insufficient support width in the infills OOP capacity. The present manuscript pretends to overview some considerations regarding the performance assessment of the infill panels OOP behaviour based on experimental tests.

Author Keywords. Masonry infill walls, out-of-plane, seismic behaviour, experimental testing, strengthening techniques

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1. Introduction

In recent years, it can be noticed the interest denoted on the study of the infill masonry walls influence in the seismic response of RC buildings. The impact of the infill can be favourable or not, depending on several phenomena (Vicente, Rodrigues et al. 2012, Romão, A.A.Costa et al. 2013, Furtado, Costa et al. 2016). From surveys damage assessment after earthquakes, many authors reported that some RC buildings were severely damaged or collapsed due to the presence of the infill panels (Furtado, Rodrigues et al. 2015).

Past and more recent seismic events worldwide clearly showed that a crucial issue for life-safety and loss reduction due to earthquakes for existing reinforced concrete (RC) buildings is related to the out-of-plane (OOP) collapse of infill masonry walls. In the last thirty years, a quite limited number of experimental tests was presented in the literature on unreinforced masonry infills in RC frames under OOP loading. Even less studies addressed the paramount topic of the strengthening strategies to prevent the infills' OOP collapse. The latter point is still a frontier issue for the most recent research works and it represents the focus of the present study.

2. Experimental study of the infill panels OOP behaviour

A large experimental campaign is being carried out in the Laboratory of Earthquake and Structural Engineering (LESE) with two major goals: i) assessment of the OOP vulnerability of

the infill panels (Figure 1b) ; ii) development of retrofit strategies to prevent the collapse (Figure 1c). For that, an innovative test setup was developed that apply a distributed OOP loading through the entire panel using pneumatic actuators (Figure 1a).

a) b) c)

Figure 1: Experimental campaign of infill panels OOP tests: a) test setup; b) cracking pattern of an as-built specimen; c) general view of a retrofitted panel.

From the OOP static testing a significant difference was found between the test results, with and without previous in-plane damage, namely: a) the maximum strength reduced about 70%; b) energy dissipation capacity reduced about 80%; c) the panel behaved as a rigid body with the detachment from the envelope frame.

3. Conclusions

In the assessment of existing buildings and in the design of new buildings, the consideration of the masonry infill walls presence should be mandatory as well as particular attention must be given to the connection of the panel to the envelope frame. Recent earthquakes evi-denced that the infill panels are vulnerable to OOP loadings, which could result in serious human and economic consequences.

Acknowledgments

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Seismic assessment of an industrial precast RC buildings

Nádia Batalha[1], Hugo Rodrigues[2], Humberto Varum[3]
[1]Estudante de Doutoramento, CONSTRUCT-LESE | Faculdade de Engenharia da Universidade do Porto (up201809163@fe.up.pt)
[2]Professor Adjunto, RISCO | ESTG, Instituto Politécnico de Leiria Portugal (hugo.f.rodrigues@ipleiria.pt)
[3]Professor Catedrático, CONSTRUCT-LESE | Faculdade de Engenharia da Universidade do Porto (hvarum@fe.up.pt)

Abstract
Precast concrete buildings are a common building typology in the Portuguese industrial park and looking to its performance in recent earthquakes around Europe it can be observed a poor performance both at structural and non-structural levels. Their characterization becomes important in order to know better its seismic behavior to mitigate the seismic risk. The one-story industrial buildings, with a frame structure of beams and columns, with a fixed connection at the base and hinged at the top, on which variable section beams are later supported is the most recurrent solution in Portugal. In this sense, this work deals with the seismic behavior of a frame of an existing industrial building, with prefabricated concrete structure. This characterization is performed through non-linear static and dynamic analysis.

Author Keywords. Industrial buildings, Precast RC buildings, Seismic performance, Pushover analyses, Dynamic analysis.

1. Introduction

In recent earthquakes, it has been observed that precast RC structures has shown in several cases a poor performance, presenting damages on structural and non-structural elements, highlighting the vulnerability of industrial buildings *(Batalha, Rodrigues, and Varum 2019; Magliulo et al. 2014; Belleri et al. 2014)* and an important part was not designed with the consideration of the seismic action or according with the recent seismic codes. Most of the observed damages are related with structural elements, namely in the connections between beam and columns and horizontal elements (beams and roof). The most common system of precast RC industrial structures in Portugal consist in fixed columns in the base and a hinged connection in the top, beams with variable section with spans up to 45 meters *(Viegas and Saraiva, n.d.)*. The solution studied in this work is based on that configuration. The present work has as objectives performing a seismic assessment of a typical Portuguese industrial precast reinforced concrete building by studying the seismic response of a frame by means of nonlinear static and dynamic methods.

2. Case study

The structure in study is constituted by a frame system constituted by 5 bays with 35.86 m of length each one, with a height of 12 m (Figure 1) design according with the actual seismic codes. The nonlinear static and dynamic analyses were performed using the structural analysis *Opensees*.

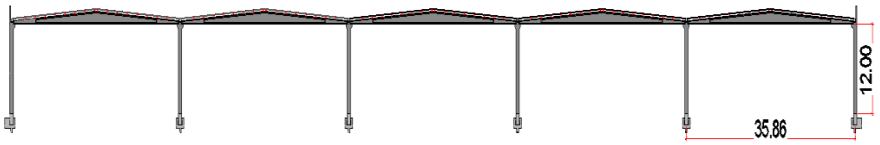

Figure 1: Representation of the structure

3. Results

The obtained pushover curve showed that the yield occurs for a drift of approximately 4% corresponding to a base shear of approximately 357 kN. For the nonlinear dynamic analysis, a set of 20 earthquake records were were selected through real seismic events, representing the EC8 response spectrum for Lisbon, soil Type C. In Figure 2 are presented the results from the IDA, the green lines correspond to earthquakes of type 1 and the yellow ones correspond to earthquakes of type 2. The dashed lines represent the value of design PGA's for type 1 and type 2 earthquakes (0.16 and 0.20 respectively). It can be observed that for the same peak ground acceleration, type 1 earthquakes cause significantly more severe displacements than type 2 earthquakes.

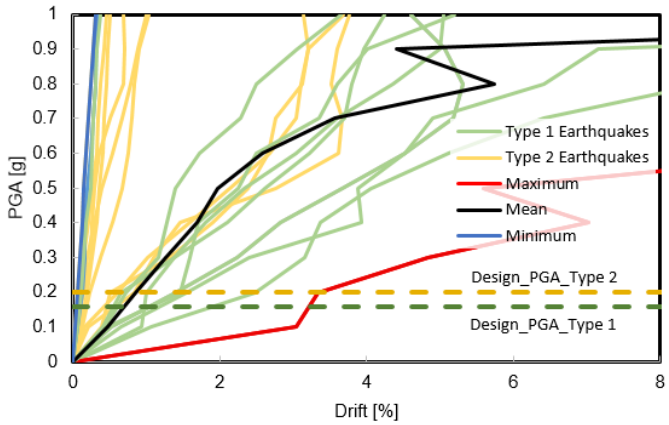

Figure 2: PGA vs Drift graphic for the different earthquakes considered in the analysis of the structure

4. Conclusions

From the analyzes performed, it can be observed that the earthquakes that most affect the seismic response are the earthquakes of type 1, which Eurocode 8 classify as being 'distant' earthquakes, verifying that the study portal has a structural behavior appropriate to the imposed actions

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Influence of seismic action on Brazilian reinforced concrete buildings: partial results

Paulo Miranda[1], Humberto Varum[2], Nelson Vila Pouca[3]
[1] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (paulo.miranda@fe.up.pt)
[2] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (hvarum@fe.up.pt)
[3] CONSTRUCT-LESE, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nelsonvp@fe.up.pt)

Abstract

Brazil is in the central region of the South American plate, being therefore a low-to-moderate seismicity country. Many earthquakes in Brazil are associated with global character tectonic movements. The tectonic forces act in fragile zones called zones of discontinuity giving rise to the earthquakes. The Brazilian seismic records, although very recent, generally point to maximum 5.5 magnitude earthquakes and by now, these events did not bring great consequences. However, some events in the recent past were reason for concern. The magnitude 5.2 earthquake occurred in 1980 in the city of Pacajus-CE and the magnitude 5.1 earthquake occurred in 1986 in the city of João Câmara-RN caused partial or total buildings collapses, many buildings had to be rebuilt or recovered and people were injured and made homeless. Depending on the depth of the focus, the soil type, the characteristics of the buildings and the exposure of people, earthquakes of this magnitude can, in fact, lead to great tragedies. Elsewhere in the world, earthquakes of magnitude like those already recorded in Brazil caused much destruction. Another aspect to consider is that even in intraplate regions, strong earthquakes have been observed causing great losses. In these regions, the strong earthquakes probability of occurrence is much lower than in the plate's boundary regions. However, the stable nature of the soils of the central plate regions leads to more efficient propagation of seismic waves, characterizing them as potential areas for catastrophic earthquakes. The damage observed in the intraplate regions can be intense, not only due to the geological characteristics, but also due to the lack of anti-seismic care in buildings and the lack of population capacity to react to the situation. In 2006, considering the seismic activity increase in Brazil in the recent years and the need to adapt Brazilian technical codes to international requirements aiming economic integration with other countries in the world, the Brazilian Association of Technical Codes published the NBR 15421 – Design of seismic resistant structures. This code deals with the obligation to consider seismic actions in new structures designs and presents a map based on World Seismic Hazard Program that divides Brazil into five seismic zones. Most of the Brazilian territory is in seismic zone 0, region where no seismic resistance requirement is necessary. Answers of a form applied to Brazilian structural engineers indicate a low knowledge level of the seismic code and the rare usage of its recommendations in structural designs. From the seismic point of view, the comfortable situation of the Brazilian scenario exposes the fragility of the structures, since, different from the vertical loads that are easily and constantly verified from the moment the structure is put to the test, the verification of horizontal loads, like seismic action, is only possible through numerical or experimental simulations, or during the actual loads application in the structures. In Brazil, in terms of research, there are few published works in the area. In these works, the structural models adopted do not represent a Brazilian city building inventory; in addition, the topographic and geological parameters assumed do not represent real situations or follow national mapping criteria. In this present work, a residential inventory building survey of the city of Fortaleza, capital of Ceará, was carried. Ceará is one of the most seismically active states in Brazil. Aspects such as number of buildings, number of storeys, age of buildings, design codes considered, and materials used were evaluated. Concrete structures are the more used system for residential buildings in Fortaleza and the city has shown a marked increase in high buildings in the last 40 years. Some buildings, especially the small and low ones are generally built without specific structural designs and made of inadequate materials. The buildings also have certain architectural and structural characteristics that raise questions about adequate behavior under seismic actions. Structural models were created from the inventory data collected and they will be submitted to the seismic action's influence evaluation. These processes aim to verify the vulnerability level of Fortaleza existing buildings and depending on

the results to raise awareness and disseminate actions for seismic risk reduction. The comparative study of NBR 15421: 2006 with seismic codes from other countries also permitted to identify the very broad aspect of Brazilian zoning map, not addressing the specific characteristics of Brazilian seismicity. Even in low-to-moderate seismicity countries, detailed seismic risk and zoning studies are justified by the high seismic risk, often caused by the high vulnerability of buildings and the large exposure of people. The Brazilian seismic records evaluation, especially since the 1980s, indicates a different configuration of the seismic hazard in Brazil. This work presents Brazilian seismicity aspects, indication of seismic vulnerability of Fortaleza's buildings and the methodology to be applied to verify the influence of seismic actions on its reinforced concrete structures.

Author Keywords. Intraplate region, Seismic vulnerability, Concrete structure.

On the applicability of conventional seismic design methodologies to hybrid RC-steel systems

Rodrigo Falcão Moreira[1], José Miguel Castro[2], Humberto Varum[3]
[1] CONSTRUCT-LESE, Faculty of Engineering, University of Porto (rodrigo.moreira@fe.up.pt)
[2] CONSTRUCT-LESE, Faculty of Engineering, University of Porto (miguel.castro@fe.up.pt)
[3] CONSTRUCT-LESE, Faculty of Engineering, University of Porto (hvarum@fe.up.pt)

Abstract
This study analyses the adequacy of the *q*-factor approach (a linear static design method with reduced input seismic action) when applied to older-type RC structures retrofitted with concentric steel braces. This approach is prescribed by EC8-1 (2004) as the basic design method and usually referred to as the most conservative. However, due to its simplicity and popularity for the design of new structures, practitioners are more likely to resort to it than to more complex nonlinear static and dynamic procedures when involved in situations requiring the seismic assessment and strengthening of existing RC buildings. The study starts by reviewing the *q*-factor approach defined in EC8-3 (2005) for the seismic assessment of existing structures and then proceeds to analyse the difficulties a practitioner will face when defining and evaluating the efficiency of a steel-brace retrofitting system within the framework of EC8-1 (2004). Afterwards, the validation of the design methodology is discussed, using nonlinear dynamic analysis to evaluate the performance of the obtained retrofitted structures according to EC8-3 (2005). Finally, an application example is presented and conclusions about the adequacy of the tested force-based methodology are drawn from the obtained results.

Author Keywords: Seismic assessment and retrofitting of existing RC structures, Concentric steel braces, Hybrid RC-steel systems, Behaviour factors, Force-based seismic design, Displacement-based seismic design.

1. Background

Seismic design is currently codified by structural codes and standards of practice using the so-called “force-based design” (FBD). This procedure involves the consideration of a behaviour factor (*q*-factor) as a mean to account for the nonlinear behaviour of the structure. However, in most structures designed according to old seismic (or even non-seismic) codes, the uncertainties about the nonlinear behaviour are relevant, making it very difficult to define a direct correlation between the real internal forces, that develop in the structural members during the seismic excitation, and those experienced by an equivalent indefinitely elastic structure. Several experimental and analytical studies have been conducted over the last years with the purpose of providing information about the seismic performance of RC buildings strengthened with steel braces. Unfortunately, only a few (e.g. Maheri and Akbari, 2003; Godínez-Domínguez and Tena-Colunga, 2010) have resulted in proposals for *q*-factors to be applied in the design. Moreover, due to the discrepancy of results, limited confidence should be assigned to these proposals. In fact, the work of the referred authors indicates that the improvement in the seismic behaviour of the RC structure, achieved with the incorporation of the steel braces, may not be proportional to the increase in lateral strength, thus suggesting that a *q*-factor based design process might not lead to good seismic performance of the retrofitted structure. As such, the nonlinear behaviour of existing and retrofitted structures should be faced directly, despite the considerable increase in complexity of the design and assessment procedures.

2. Relevant results

The RC building chosen as a case study is representative of the design and common construction practice in Southern European countries until the late 1970's. Behaviour factors *q* corresponding to two different ductility classes (DCM and DCL) were considered to obtain the seismic forces on the retrofitted structure. After sizing the two retrofitting systems and checking the safety of the RC elements, nonlinear dynamic analyses were run in order to assess the seismic performance of the retrofitted structures. A distributed plasticity model with fibre discretization (Fig. 1) was developed using the software package *SeismoStruct* (Seismosoft, 2018). The obtained results indicate that: (i) the DCM retrofitting system was unable to reduce the seismic demands on some of the RC members to levels below the corresponding capacities and (ii) the DCL retrofitting system induced compression forces in one of the RC columns high enough to cause it to collapse during a seismic event (Fig. 2). Hence, even though the design process of the retrofitting system indicated both solutions as acceptable, the results of the seismic assessment process proved them ineffective together with the considered *q*-factors.

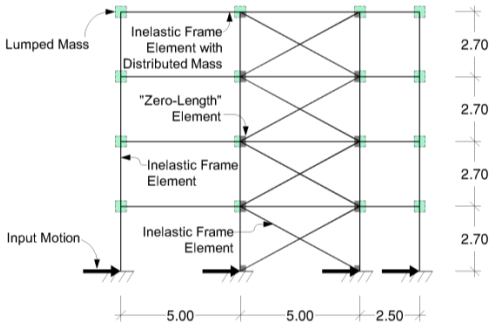

Figure 1: Numerical model

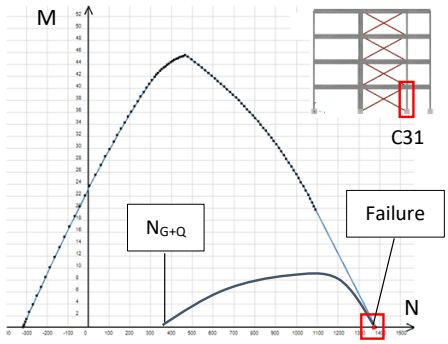

Figure 2: N-M interaction diagram

3. Conclusions

The conducted study shows that the force-based design process gives no guarantees in terms of adequate seismic behaviour of the retrofitted structure. Further research is thus needed to develop a performance-based methodology that takes explicit consideration of the interaction between both structural systems (RC structure and steel braces), namely the influence of the steel braces' resistance on the deformation capacity of the RC elements.

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ANALYTICAL STUDY FOR FORMS AND DIMENSIONS OF MINARETS IN ALGERIA

BELDJILALI Said[1], BOUGARA Abdelkader [2], VARUM Humberto [3],
University of Abdelhamid Iben Badis de Mostaganem, Algérie [2] Université of Hassiba Benbouali de Chlef, Algérie- [3] University (FEUP) Porto, Portugal

Abstract

The Islamic heritage constitutes a very precious treasure in Algeria; it provides the image of these cities as KSOUR (castles) and individual houses types Haouche but especially the places of worship (mosques) which express the symbol of this architecture. They are considered as important landmarks of Algerian cities through these architectural elements such as the dome and the minaret. There is a lot of research on the behaviour of religious elements such as temples in the Nepalese pagoda or cathedrals. First, these minarets are used by the muezzin to invite people to prayer; they were previously built near the mosque or inside it next to the prayer room, later they appeared as angle towers. of mausoleums. During 1400 years of Islamic civilization, a numerous forms of minarets are developed. The minarets in Algeria of the medieval period (Bani Hamad, Eelmorafid, Zianides, Mérinides and Ottomane) were selected, and then classified according to several typologies, (dimensions, forms, design ...). This research is part of an analytical study of minarets in Algeria and its evolution over time. The main objectives of this work can be summarized in the search for the forms that determine the typology of minarets and to draw a canevas for the features and architectural elements, varying and invariant of minarets of each period. Look for an identity and an original architectural reference of each period is also targeted in this investigation. The methodology followed in this analysis is that of the monographic method which relies on observation and field work while introducing a thorough reading of history. The results found from this analysis showed that the rectangular shape of the main tower of the minaret represents 2/3 with the same dimensions between the top and bottom, whereas the square shape of the section of the main tower of minarets represents ½ which symbolizes the most earthquake resistant form.

Author Keywords.

Minarets, ornaments, originality, report, heritage..

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Commentaire [JPP1]: When citing authors should use the author-date system, which means including in the text and between curved brackets, the last name of the authors and the date – example (Smith 2005). The complete reference should be listed at the end of the document using the Chicago Manual of Style. Instructions and examples of references can be found at http://www.chicagomanualofstyle.org . Authors can use tools like EndNote or Mendeley to support this process.

Advanced Methodology for Monetary Loss Estimation of Reinforced Concrete Frames

Tuba Tatar[1], Mario Marques[2], Mario Pimentel[3] , Jose Miguel Castro[3]
[1]PhD Student at University of Porto
[2]Investigator at University of Porto
[3]Assistant Professor at University of Porto

Abstract

While seismic risk assessment is the first step of understanding the impact of earthquakes and the need of seismic rehabilitation, it is important for both pre-earthquake preparedness and awareness to provide an accurate estimation of the human and economic losses that are likely to occur in a certain region. The aim of this paper is to present a new methodology for analytical and trustworthy seismic risk assessment of reinforced concrete moment resisting frame buildings. This procedure is deemed crucial for regions in where although their moderate to high seismicity (i.e. Portugal) there is a lack of robust post-earthquake data to derive empirical relationships between damage and cost to repair and thus, to develop appropriate risk management decisions from cost-benefit analyses.

Author Keywords. Seismic risk assessment, damage, loss ratio, axial load.

1. Introduction

Aiming to improve the accuracy of repair cost calculations, so that it is possible to provide an alternative approach for regions in which there is not a proper consequence function that relates each damage level to its cost of repair and to form a new damage index for each structural element type, a new advanced methodology is proposed. The proposed methodology consists of two main phases named as *'Local Aspect*'-(Phase 1) and *'Global Aspect*' -(Phase 2). This approach consists of defining the damages that can be experienced by the structural elements during seismic actions in a more accurate and detailed way than the conventional methods. While the physical damages due to the deterioration in mechanical properties of the materials under repeated cyclic loading are correlated with the engineering demand parameter(s) (EDPs), changes in response in a local sense, at the material levels, are associated with the physical damages. Thresholds for each damage states are formed from the scratch and discretized into several axial load levels.

2. Materials and Methods

The first phase of the methodology which deals with damage determination the in local sense investigates the behavior of each individual structural element through the development of a complex finite element numerical model under cyclic loading. This procedure is followed for the characterization of the structural performance of five different columns, which are modeled and assessed numerically using the software DIANA (BV, 2014); one of the columns was tested at University of Porto (UP) (Rodrigues, 2012), while the remaining ones were selected from studies existing in literature, sharing the same material and geometrical properties but have the different axial load levels (Denpongpan & Shima, 2005). The second phase corresponds to the assessment of the nonlinear performance of a full frame structure, modeled under seismic loading, using a simplified model with the open source tool OpenSees (OpenSees, 2006). This paper presents an application of the proposed methodology to estimate the expected loss ratio through the employment of numerical modeling and

incremental dynamic analysis. The methodology is applied to a residential building under eleven sets of records (total 550 real earthquake records) and applications are completed successfully. Additionally, the results are computed regarding the axial load level in the structural elements based on two EDPs: drift (global EDP) and rotation (local EDP).

3. Discussion

Figure 1 (a) and (b) show the loss ratio of the structure under increasing dynamic loading where the selected EDPs are drift and total rotation, respectively. It is observed that the loss ratio is higher when global EDP is considered because after the damage state is reached, the physical damage and monetary loss are calculated as a full element. However, the local EDP investigates the damage on an element region by region and the computed loss ratio becomes smaller. Figure 1 (c) compares the results using the proposed methodology with the simplified approach, i.e. story-based loss estimation. The simplified approach provides more conservative results especially, the difference is growing under higher intensities. Figure 1 (d) investigates the influence of the axial load level on the loss estimation.

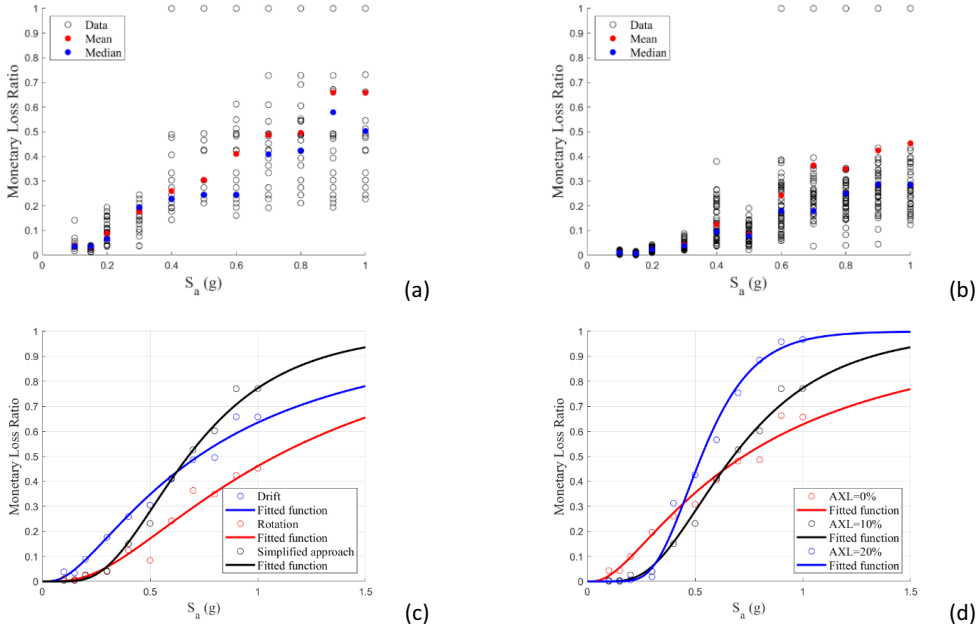

Figure 1: Monetary loss ratio for a residential building a) EDP is drift, b) EDP is rotation, c) Comparison of the methodology, d)Axial load influence

4. Conclusions

The proposed methodology provides a lower loss ratio specifically when higher seismic intensity is applied. The selected EDP plays a role in a loss estimation; the local EDP offers smaller loss ratio than the global EDP. Importantly, the axial load level in the structure shall be taken into account while assessing damage and loss in a structure.

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Enhancement of Construction On-site Quality Control based on new IT

Rui Bessa[1]

[1] Construct-GEQUALTEC, Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (ruibessa07@gmail.com) ORCID 0000-0001-7008-7533

Abstract

Construction Quality Control on-site reacts to facts and lacks a systematic and based on real-time data approach. The shortcomings of this control directly affect the quality of the product, having an impact on direct and indirect costs. Moreover, it allows systematic errors to occur in construction projects, making it difficult to determine its causes and origins, thus preventing their mitigation through preventive actions. The presented work aims to develop a framework for on-site compliance checking that integrates "As-built" information in the quality records. The goal of the developed framework is to classify on-site control information to enable timely actions based on real-time data in order not only to prevent and mitigate defects occurrence but also to evaluate quality control performance. The developed framework was tested on the construction site, in a case study context. The presented work shows greater assertiveness of compliance checking at lower costs and provides complete records with organized information.

Author Keywords. Quality Control, On-site Compliance Checking, Construction Information Systems, Quality Management.

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Air permeability of buildings with modular light construction systems in southern Europe: gaps and needs

Vitor E.M. Cardoso*[1], Nuno M.M. Ramos[1], Ricardo M.S.F. Almeida[1,2] and Manuela Almeida[3]

[1] University of Porto, Faculty of Engineering, LFC - Laboratory of Building Physics, Porto, Portugal (v.cardoso@fe.up.pt) ORCID 0000-0002-4886-2406 (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429

[2] Polytechnic Institute of Viseu, School of Technology & Management, Civil Engineering Department, Viseu, Portugal (ralmeida@estv.ipv.pt) ORCID 0000-0002-9846-6081

[3] University of Minho, Civil Engineering Dep., Centre for Territory, Environment and Construction, Guimarães, Portugal (malmeida@civil.uminho.pt) ORCID 0000-0003-2713-6322

Abstract

Modular light construction systems are a recent trend in mild climate countries of southern Europe. Still, several gaps on their design must be filled for them to be a viable option in the future. A fitting air permeability approach is one of these challenges. In this short paper several topics on the issue will be presented and gaps and needs will be discussed. Conclusions on how to achieve high performance air permeability in the context of southern Europe will be made.

Author Keywords. Air permeability, Airtightness, Modular light construction, Energy efficiency, Ventilation, Building simulation.

1. Introduction

Air permeability in buildings is a complex issue, it impacts health and thermal comfort of occupants and influences HVAC systems efficiency, materials durability and energy loads of buildings (Lstiburek, 2008). Air permeability is commonly assessed through airtightness measurements and models. Airtightness represents the resistance to these unintentional air trades. This parameter is more easily measured and allows the comparison of performance between buildings. Modelling on this topic relies on empirical data analysis and theoretical tools development. Figure 1 presents some of the most important factors influencing it.

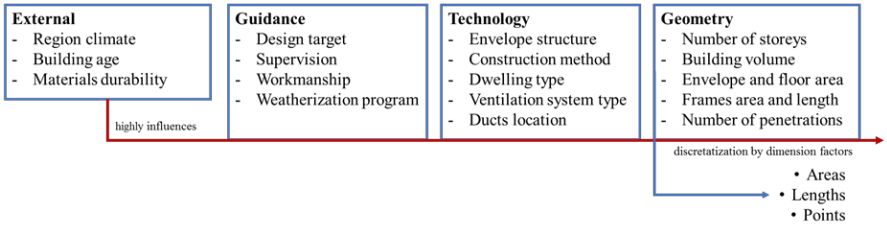

Figure 1: Airtightness influencing factors by categories

Modular light construction often presents a better control of geometry configurations leading to a better prediction of probable air leakage paths and a superior level of technology assembly efficiency which consequently provides improved and less variable construction procedures for workers to follow during the whole fabrication and construction processes. Properly addressing air permeability is essential in Europe's ambition of a correct implementation of the nearly zero energy buildings (nZEB) (European Comission, 2018)

strategy without harming its population health. Modular light construction systems exhibit a promising outlook on the implementation of such a strategy.

2. Gaps and needs

In Europe, air permeability requirements are a reality in several countries in the center and in the north. In the countries of the South of Europe, with milder climates, no requirements on air permeability are established (Meiss & Feijó-Muñoz, 2015). Although airtightness is a complex subject dependent on the influence of several variables, its requirements are usually defined taking into account only part of these variables. External factors will influence all others: workmanship; technology; geometry. The latter are clearly associated with air leakage paths. Less complex infiltration models require less computational capacity but add more uncertainty in the analysis. more complex models allow to obtain, with a correct discretization, more reliable results but at the expense of such a high computational capacity that in practice prevents the execution of sensitivity analyses. Constituent elements of the enclosure need to meet requirements for the enclosure to have a correct air permeability performance. Several needs are identified in the present in order to tackle this issue:

- Adopt a methodology that includes a greater number of variables and establish appropriate air permeability requirements to the specificities of Southern Europe.
- Direct the study of influencing factors through the characterization of air leakage paths taking into account information related to geometry and technology, such as the type and connection of the elements in question.
- Combine simpler modeling components with more complex ones that allow more reliable sensitivity analyzes to be performed.
- Properly select envelope elements on meeting requirements on durability, constructability, embodied energy and compatibility among them.

3. Conclusions

It can be concluded that the definition of what is required for buildings to have adequate air permeability performance ranges and which technologies are more capable of attaining them is at the center of the research that needs to be developed. For that it is proposed to:

- Create a methodology for the definition of envelope permeability requirements.
- Define recommended envelope permeability performance ranges in the context of Southern Europe.
- Assess the permeability performance of sustainable modular building solutions.

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An Initial Approach to Automatic Building Information Modelling

Luís Sanhudo[1], João Poças Martins[2], Nuno M. M. Ramos[3]
[1] CONSTRUCT-GEQUALTEC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (lpnsanhudo@fe.up.pt) ORCID 0000-0002-2578-6981
[2] CONSTRUCT-GEQUALTEC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jppm@fe.up.pt) ORCID 0000-0001-9878-3792
[3] CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429

Abstract
In the last few years, although there has been an increasing need to accurately acquire structured and semantically enriched 3D digital models of existing buildings in the Architecture, Engineering and Construction (AEC) industry, currently, no software has ensured the direct shift from point clouds to complete enriched BIM models. In fact, despite recent efforts from software to import point clouds into their modelling environment, the subsequent modelling process still remains largely manual, time consuming, labour-intensive, subjective, and error-prone.
To help solve this issue, the authors propose a twostep framework where building elements are initially segmented and identified in point clouds using machine learning techniques, followed by their automatic modelling within appropriate Building Information Modelling (BIM) authoring software. This oral communication will focus on an initial approach to the second step of this framework.

Author Keywords. BIM, software, building elements, automatic modelling.

Type: Oral Communication

1. Introduction

As several works have identified (Tang et al. 2010, Macher, Landes, and Grussenmeyer 2017, Huber et al. 2011), the AEC industry requires a method for the expeditious, accurate and automatic BIM modelling of existing buildings. Recent efforts have focused on the importation of point clouds into the modelling environment, followed by a manual modelling of the building using the point clouds as reference. However, research indicates this to be a largely manual, time consuming, labour-intensive, subjective, and error-prone method (Tang et al. 2010, Macher, Landes, and Grussenmeyer 2017). This communication will focus on an initial approach to the second step of a twostep framework, where after the building elements are automatically segmented and identified in points clouds, their subsequently modelling within BIM authoring software is performed.

2. Materials and Methods

Throughout this research, the authors applied the software Autodesk Revit, as the chosen BIM authoring tool, and Dynamo, a visual programming language for Revit.

3. Discussion

To achieve the automatic modelling of a building, the authors developed a plugin for Autodesk Revit using Dynamo. This plugin receives information regarding a building's constructive elements as an input and creates the building's respective BIM model as its main output. The inputs originate from the segmentation and identification of the building elements within the point cloud, the first step in the proposed framework.

In the current version of the software, five building elements can be automatic modelled: walls; floors; ceilings; doors; and windows. The inputs for the modelling of each element can be seen in Table 1.

Building Element	Inputs
Walls	Family Type; Corners Coordinates
Floors and Ceilings	Family Type; Corners Coordinates
Doors and Windows	Family Type; Centre Coordinate

Table 1: Software inputs

Regarding the workflow of the plugin, the software initially uses the building elements' coordinates to establish their correct location and geometric dimensions. Afterwards, each element geometry is enriched with semantical content through the linkage of the indicated element family type, an Autodesk Revit attribute. It should be stated that original parametric families were created to not only facilitate dimension modification but also further enrich the displayed information. Figure 1 displays a portion of the plugin code, as well as a BIM model obtained using the plugin.

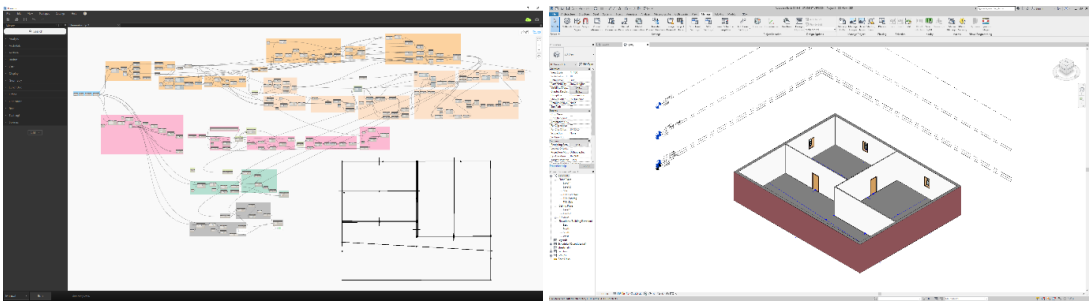

Figure 1: Plugin code in Dynamo (left); BIM model acquired with the plugin (right)

4. Conclusions

As previously stated, this research encapsulates an initial approach to automatic BIM modelling. The created software has been tested to perform successfully in what the authors think would be the majority of cases. However, when faced with complex geometries (e.g. tilted walls), the current version of the software struggles to properly model the building. Options to solve this issue, based on the vectorization of the building elements and the identification of the planes containing them, are currently in study.

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Acknowledgments

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Balcony spaces: the impacts on indoor environment and energy efficiency

Catarina F. T. Ribeiro[1], Nuno M. M. Ramos[2], Inês Flores-Colen[3]

[1] CONSTRUCT-LFC, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (catarina.cato@gmail.com) ORCID 0000-0001-8671-0457
[2] CONSTRUCT-LFC, Faculdade de Engenharia da Universidade do Porto (FEUP), Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal (nuno.ramos@fe.up.pt) ORCID 0000-0002-5331-7429
[3] CERIS, DECivil, Instituto Superior Técnico (IST), Universidade de Lisboa, Av. Rovisco Pais, Lisboa, 1049-001, Portugal (ines.flores.colen@tecnico.ulisboa.pt) ORCID 0000-0003-4038-6748

Abstract
The balcony is a space in-between that has the ability to mediate the outdoor and the indoor environment. This communication provides a holistic review of the impacts of balcony morphology on the indoor environmental conditions and the energy performance on dwellings.

Author Keywords. Balcony space, Comfort, Indoor environment quality, Energy efficiency.

Type: Oral Communcation
Open Access Peer Reviewed CC BY

1. Introduction

The balcony is a space in-between that has the ability to mediate the outdoor and the indoor environment. Several terms has been used to define balconies capacity to modify the outdoor conditions: environmental filter; environmental buffer spaces; buffer zone; transitional zone; intermediate spaces; and mediator space.

Nowadays, the energy reduction on dwellings is still on major importance to mitigate the role of buildings in total world energy consumption. In this regard, the main objective of this communication is to provide a holistic review of the impacts of balcony morphology on the indoor environmental conditions and the energy performance on dwellings.

2. Balcony spaces impacts

For a proper understanding of the impacts of the morphology of balcony spaces in dwellings it is proposed on this research a division of balcony spaces in four typologies, represented on fig. 1: balcony (B); shaded balcony (SB); glazed balcony (GB); and eliminated balcony (EB). On the communication it will be included a systematization of the wide range of effects produced by each balcony morphology and the analysis of their consequent impacts on indoor environmental conditions and energy efficiency.

3. Conclusions

The review of balcony impacts in the indoor contiguous space of dwellings, confirmed the importance to find a balance between the distinct impacts in order to provide a good internal environment with a minimum of energy consumption.

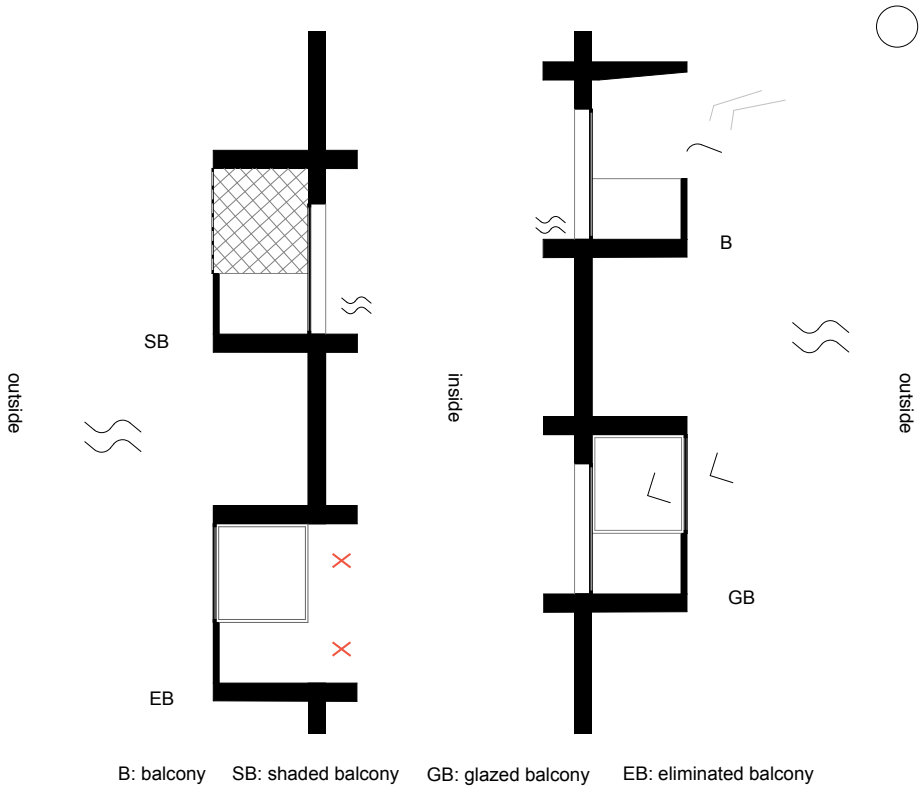

Figure 1: Balcony spaces

Moreover, this communication aims to discuss the suitability of balcony spaces for different climates, the near surrounding, the occupants' preferences and the cultural concerns.

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Comfort evaluation of dwellings located in historical buildings in southern Europe

Sílvia A. Magalhães[1], Vasco Peixoto de Freitas[1]
[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (silvia.magalhaes@fe.up.pt; vpfreita@fe.up.pt)

Abstract
The thermal performance evaluation of buildings relies on the European Directives on Energy Performance of Buildings, providing the framework on which all member states should improve their buildings 'energy efficiency'. However, it is established in several literature, there is an important gap between normative calculations and measured consumptions. In Portugal, this is explained by a mild climate and a high fuel poverty phenomena. Thus, for low heating countries, the thermal performance should rely on the discomfort minimization. It was performed the comfort assessment of dwellings located in the typical building with massive walls and wooden pavements and roof, with or without insulation on walls, for different orientations. The numerical model was validated with experimental data. The comfort was assessed considering the adaptive approach of the European Norm 15 251, for free running conditions, or with low heating profiles. Results show the insulation introduction has a very small impact on discomfort minimization, for low heating profiles in mild climates, what shall be considered, bearing in mind it presents many times technical difficulties in historical buildings.

Author Keywords. Comfort evaluation; Adaptive comfort; Southern Europe, Low heating, Energy Certification

Type: Oral Communication
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1. Introduction

There are around 3,5 million of buildings and 5,9 million of dwellings for around 10,5 million inhabitants in Portugal. Around 34% need some type of intervention and half of those need expressive rehabilitation to re-establish the actual comfort and safety requirements. On the other hand, since the 2002/2010 Energy Performance of Buildings Directives, there is an opportunity to enhance the thermal and energy performance of all the buildings needing some type of retrofitting works, and for the historic buildings in particular. The energy needs calculation methodology and the minimal requirements imposed consider permanent heating/cooling habits, specially heating in winter, having as referential, the "heating degrees days" (HDD) parameter. Although, these methodologies have no account for specific and realistic heating/cooling habits, as for southern European countries with mild climates.

2. Mild climate, Fuel poverty and low heating patterns in Portugal

Portugal has 1155ºCd, 63% less "heating degrees days" (HDD) than EU-28 average of 2817ºCd. Nevertheless, several studies focusing on Fuel poverty – defined as "*lack of affordability of energy for heating*" (Boardman, 1991) - places Portugal in the worst positions. High energy costs and low incomes explains it. Mainly for these two reasons, space heating weight in Portuguese average household energy bill is only 21% of the total consumption and 11% of the total cost. On the European average bill, space heating weight 67%. So, for Portugal as other low heating countries, it is considered more important to rely the thermal performance

on the comfort evaluation, instead of energy consumptions, which are already low. European norm EN 15251 presents an adaptive approach to assess comfort inside buildings.

3. Case study and results

It was carried out a monitoring campaign (2016) in two dwellings in a XIX typical building, located in Porto, measuring temperature and relative humidity. It has been developed a numerical model on ©WUFIPlus software for both dwellings. The model was validated with 0,5ºC of maximum temperature difference and 3,5% for humidity relative maximum difference. It was evaluated the discomfort by the adaptive approach from EN 15251 Normative, for both Porto and Lisbon. Two external walls were evaluated: non insulated '0cm' (U=2W/m2ºC), and insulated '6cm' (U=0.48W/m2ºC), placed by the interior side of external walls (the only option in many historic buildings), for north and south orientations. Other parameters are fixed and defined as: between floors apartment (area=52m2); ventilation=0,5 air change rate per hour; Occupation: 2 persons (0.97met); Awin/Apav=22,3%; Openings: Uw=2,8/Uwdn=2,2/Solar factor=0,75; solar protection activation mode: "reduce overheating T>25ºC"; boundary conditions: adjacent buildings and up and bottom floors having the same inner climate. Results are presented in Figure 1 for Porto and Lisbon climates.

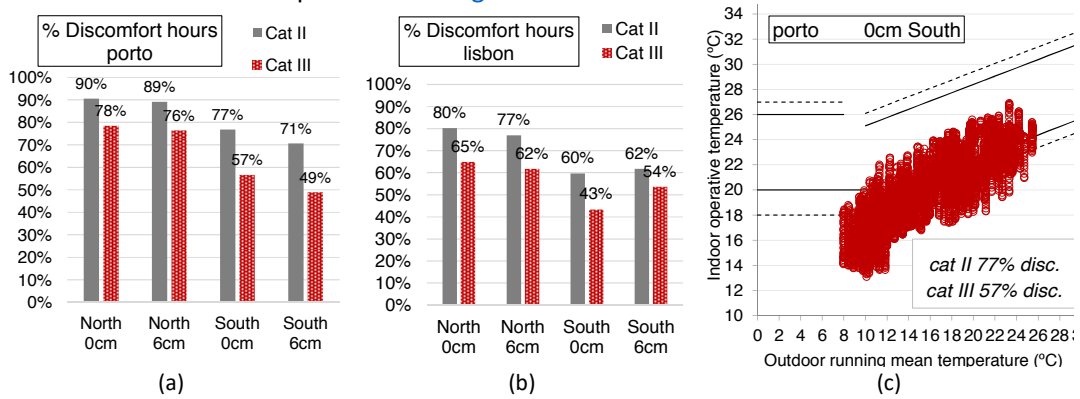

Figure 1: (a) Porto 0cm; (b) Porto 6cm; (c) Lisbon 0cm; (d) Lisbon 6cm.

4. Discussion and conclusions

The results obtained (Figure 1), with or without 6cm insulation, shows that its impact on discomfort minimization is very small in a free floating profile, both for Porto and Lisbon climates. Much more important is the orientation. For Porto climate and north orientated, the discomfort reduction is only 1% of the time for category II (retrofitted buildings). Thus, the decision of introduction insulation in historical buildings with architectural value, shall be well evaluated, especially when located in temperate climates and fuel more vulnerable countries, where intermittent heating habits prevail. Also, it is essential to evaluate thermal performance using advanced thermal simulation, and a complementary approach is needed, besides the Energy certification schemes, focusing on discomfort instead of energy consumptions.

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A classroom prototype refurbishment – heating strategies and comfort

Francisca Cavaleiro Barbosa[1], Vasco Peixoto de Freitas[1], Manuela Almeida[2]

[1]Construct-LFC, Department of Civil Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (francisca.barbosa@fe.up.pt, vpfreita@fe.up.pt)

[2]CTAC, Department of Civil Engineering, School of Engineering, University of Minho, Campus de Azurém . 4804 - 533 Guimarães, Portugal, (malmeida@civil.uminho.pt)

Abstract

Portuguese school buildings are generally characterized by an in service thermal discomfort, due to the poor envelope thermal properties and the lack of resources for paying energy consumption. This work studies the Portuguese *Brandão* schools model. A prototype classroom was prepared in a *Brandão* school, in Porto. Some studies were carried out regarding the thermal behavior before and after the prototype refurbishment, by experimental monitoring. The prototype construction has included the improvement of the envelope and of the technical systems. This work presents the prototype thermal performance after the refurbishment in free-running conditions and with some intermittent heating strategies. Discomfort indexes have been developed for the assessment of the discomfort.

Author Keywords. School buildings, prototype, experimental monitoring, heating strategies, thermal comfort.

Type: Oral Communication

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1. Introduction

The physical environment affects teaching and learning and this justifies the investment in users comfort and indoor air quality (Bako-Biro 2012). Portuguese schools are free-running buildings with a natural ventilation strategy. In the recent past, 175 Portuguese schools were refurbished. The investment reached 2400 million euros (IGF, 2011). Despite the high quality of the intervention, these refurbishments have not fully considered our climatic diversity and economic reality. This work studies the Portuguese *Brandão* basic schools. About 100 non-refurbished *Brandão* schools will require some interventions in the near future.

2. Prototype

A prototype classroom has been studied in a *Brandão* school, in Porto. The main goal was the assessment of the classroom behavior before and after the intervention and the calibration of an advanced hygrothermal numerical model. The following interventions were implemented (Figure 1): electric heating system; partition wall between the classroom and the circulation zone; ventilation system; exterior blinds; roof insulation. The experimental campaign consisted in the continuous monitoring of temperature (T), relative humidity (RH), CO_2 concentration (CO_2) and energy consumption (EC).

Figure 1: Prototype interventions.

3. Discomfort indicators

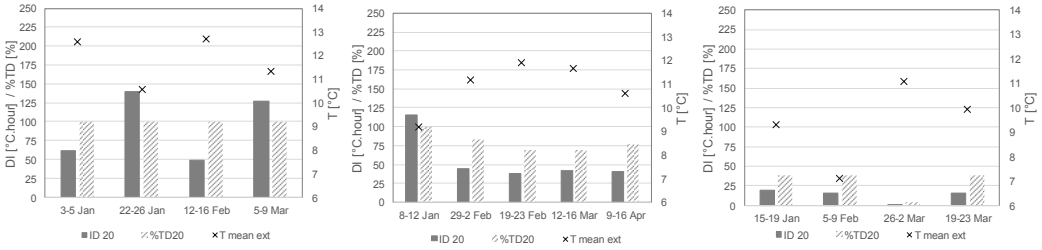
The discomfort index for winter ($DI_{w,b}$) is the sum of positive differences between comfort temperature (20°C) and the experimental hourly temperature in each period t_i, in °C.hour (Formula 1). The discomfort percentage of time ($\%DT_b$) represents the proportion of the discomfort periods during the analyzed occupation period (Formula 2).

$$\mathrm{DI}_{w,b} = \sum_{t_i}^{t_n} (\theta_b - \theta_i) \text{ , when } \theta i < \theta_b \quad (1)$$

$$\%DT_b = \sum t_{i\,discomfort} / \sum t_{i\,occupation} \quad (2)$$

4. Results and discussion

After the refurbishment the prototype was analyzed in three situations: (a) free-running T; (b) reduced heating strategy (3hours/day) and (c) regular heating strategy (10hours/day) (Figure 2). Table 2 presents the mean daily $DI_{w,20}$, $\%DT_{20}$ and energy consumption for each strategy. The $\%TD_{20}$ decreases from 100% to 80% (mean values) from the adopted strategy (a) to (b) and to about 30% for the (c) heating strategy. $DI_{w,20}$ decreases from 25.2 to 11.9 °C.hour when comparing free-running T to 3 heating hours and to 2.5 °C.hour with 10 heating hours.



(a) (b) (c)

Figure 2: Weekly $DI_{w,20}$ and $\%DT_{20}$ for (a), (b) and (c) strategy

	Heating strategy	Energy [kWh]	$DI_{w,20}$	$\%DT_{20}$
daily mean	(a)	0	25.2	100%
	(b)	10	11.9	80%
	(c)	36	2.5	29%

Table 1: Daily mean energy consumption, $DI_{w,20}$ and $\%DT_{20}$ for each heating strategy

5. Conclusions

The comfort T (20°C) during all the occupation period was only possible with the (c) heating strategy, which represents an energy consumption of 36 kWh/day per classroom. This work pretended to give a contribution for the refurbishment of school buildings in free-running conditions or with intermittent heating strategies, regarding the typical in service conditions in these kind of schools and the actual capacity to support the operating costs.

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Green Roofs – An experimental setup to measure the hygrothermal performance and comfort conditions

Sara S. de Freitas[1], Nuno M.M. Ramos[2], Hartwig M. Künzel[3], Daniel Zirkelbach[4]

[1]LFC – CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (sarafreitas@fe.up.pt)
[2]LFC – CONSTRUCT, Departamento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt)
[3]Fraunhofer Institute for Building Physics IBP, Holzkirchen Branch Fraunhoferstr. 10, 83626 VALLEY, Germany (hartwig.kuenzel@ibp.fraunhofer.de)
[4]Fraunhofer Institute for Building Physics IBP, Holzkirchen Branch Fraunhoferstr. 10, 83626 VALLEY, Germany (daniel.zirkelbach@ibp.fraunhofer.de)

Abstract

Green roofs are a spreading technology due to many benefits being reported at several levels: city, building, component and users. The advantages include improvement of the urban environment, enhancement of comfort conditions, and reduction of energy consumption. Consequently, the measurement of the real hygrothermal behaviour of green roofs is a key aspect for the design and validation of solutions.

This work focuses on the results of an experimental setup campaign for a green roof test building located in Porto which is characterized by a Mediterranean/Atlantic climate. The monitored data include temperature profiles, water content profiles, near surface heat fluxes, roof surface temperature and air temperature profiles above the roof surface. The experimental results obtained show a strong influence on the surface temperature and exterior heat fluxes during summer compared to the performance of the conventional roof. However, the impact on air temperature and relative humidity proved to be of minor significance.

Keywords green roofs, hygrothermal performance, comfort, experimental measurements

Acknowledgments

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Non-proprietary UHPFRC for use in rehabilitation/strengthening applications

Ana Mafalda Matos[1], Sandra Nunes [2], José L. Barroso-Aguiar [3]
[1] Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (up200505574@fe.up.pt)
[2]Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (snunes@fe.up.pt) ORCID 0000-0002-4876-2587
[3] Escola de Engenharia da Universidade do Minho (aguiar@civil.uminho.pt) ORCID 0000-0003-3954-5721

Abstract
Ultra-High Performance Fibre Reinforced Composites (UHPFRC) are produced with a high content of binder, low water-to-binder ratio, short high-strength steel fibres, and absence of coarse aggregates. The mix-design of UHPFRC involves a reduction in porosity, improvement in microstructure and homogeneity of the matrix phase, which combined with a sufficient amount of steel fibres provides distinctly high compressive strength (>150MPa), improved tensile behaviour (10-20MPa tensile strength with 3-10‰ strain-hardening), and excellent durability. Due to these superior properties, UHPFRC has great potential for the next generation of infrastructures - more resilient and sustainable -, but more efforts are needed to turn it into a widespread 'regular' technology (Azmee and Shafiq 2018).
Within the current PhD, for the first time, the spent equilibrium catalyst (ECat) - generated in the oil refineries – was studied as an internal curing agent to reduce UHPFRC autogenous shrinkage without impairing mechanical properties and durability (Matos et al., n.d.). The typically very high autogenous shrinkage of UHPFRC is a major concern to ensure long service life due to the early age cracking risk, namely, when the deformations are restrained as is the case in rehabilitation/strengthening applications.
Results showed that the incorporation of ECat, and the corresponding extra water that the ECat can absorb, lead to a significant reduction of the autogenous shrinkage of UHPFRC; exhibiting similar performance to the commercial products often used for internal curing, such as superabsorbent polymers and very fine lightweight aggregates. The use of ECat in UHPFRC also has the potential of enhancing the hydration due to more availability of water in the system and to its high pozzolanic activity (Nunes and Costa 2017). This allowed achieving a new UHPFRC mixture with comparable performance but lower cement content, with advantages regarding the cost and the CO_2 emissions. Moreover, the replacement of the natural sand with a residue allows both limiting the excessive exploitation of natural resources and a waste recycling that is diverted away from landfills.

Author Keywords. UHPFRC, spent equilibrium catalyst, Autogenous shrinkage, Durability, Sustainability.

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Ecological, Photocatalytic, Superhydrophobic and Self-Cleaning Asphalt Pavement Surfaces

Iran Rocha Segundo[1], Salmon Landi Jr.[2], Elisabete Freitas[3], Joaquim Carneiro[4]

[1] Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal (iran_gomes@hotmail.com),
[2]Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal and Federal Institute Goiano, Rio Verde – GO, Brazil (salmon.landi@ifgoiano.edu.br),
[3]Civil Engineering Department, University of Minho, Azurém Campus, Guimarães, Portugal (efreitas@civil.uminho.pt),
[4]Physics Department, University of Minho, Azurém Campus, Guimarães, Portugal (carneiro@fisica.uminho.pt).

Abstract

The aim of this research is to develop multifunctions on recycled asphalt mixtures for the surface layer of road pavements. Therefore, preliminary research on functionalization has been carried out. Afterwards, the asphalt mixtures were designed and characterized by mechanical and superficial point of views. The next step is the design of the nanomaterials, their application on asphalt mixtures and the characterization from physical, mechanical and superficial behavior.

Keywords. Photocatalysis, Superhydrophobic, Self-Cleaning, Surface Characteristics, Recycled Asphalts Mixtures.

1. Introduction

Currently, there is a growing concern about pollution and environmental damage. The surface layer of road pavements, besides being viable from the mechanical technical point of view, must have appropriate characteristics in terms of comfort, road safety and be sustainable (Noyce et al. 2005). The integration of nano/microparticles in Hot Mix Asphalt (HMA) provides new capabilities (functionalization) such as: photocatalytic, to photodegrade pollutants for the purpose of air cleaning; superhydrophobic, to improvement road safety; self-cleaning, to avoid slipping problems (Nahvi et al. 2018; Hassan et al. 2012). This research aims to design a multifunctional recycled HMA for the surface layer of road pavements with these capabilities.

2. Preliminary Research

A preliminary research was essential to combine the concepts of Civil Engineering and Physics. For this, two Hot Mix Asphalt mixtures (HMA), AC 6 and AC 14, were functionalized by volume incorporation of nano-TiO_2, and spraying coating a nano-TiO_2 and/or micro-ZnO aqueous solution. Their materials were characterized by Atomic Force Microscopy (AFM), Fourier Transform Infrared Spectroscopy (FTIR), and the mixtures were characterized by Water Sensitivity (WS), Permanent Deformation (PD), Fatigue Resistance (FR), Water Contact Angle (WCA) and photocatalytic efficiency.

2.1. TiO_2 and/or ZnO semiconductors particles on AC 14 and AC 6 HMA

The superhydrophobic property was developed for AC 14 TiO_2, AC 14 TiO_2 ZnO and AC 6 TiO_2 ZnO by spraying coating. The best photocatalytic efficiency was achieved for AC 14 TiO_2 ZnO.

2.2. Semiconductors Influence on Mechanical, Superficial and Photocatalysis

The WS of the HMA functionalized by volume incorporation reduced. Before abrasion, the photocatalytic efficiency was higher for the spraying coating technique than for the volume

incorporation, while after abrasion, it was the opposite. Furthermore, the functionalization techniques conducted to a difference in friction between -7% and 3%.

3. Materials and Methods

AC 10 Surf Elaster 13/60 was decided to proceed the research after the analysis of the preliminary results. AC 10 was designed without recycled materials and with 30% of Reclaimed Asphalt Pavement (RAP) and Steel Slags (SS). The HMA were evaluated by the mechanical and superficial tests. TiO_2 activates only with UV-light with a band gap of about 3.20 eV. To activate it on visible light (doping), a first approach was carried out using urea by ball milling technique. The powders were characterized by FTIR and diffuse reflectance spectroscopy.

4. Results

4.1. HMA Characterization

The HMA were mechanically characterized by WS, PD, FR, and functionally by friction, macrotexture, mechanical impedance, sound absorption. Considering the both characteristics, the best recycled HMA was the one with Steel Slags.

4.2. TiO_2 doping

In order to reduce the band gap (activation energy) of the semiconductors, nano-TiO_2 was mixed with urea by the ball milling technique, variating the percentages, rotation speeds and also time. The minimum band gap achieved was 2.97 eV, corresponding to the visible light violet. Other techniques and approaches will be carried out in order to ensure the doping.

4.3. Aging Resistance of Asphalt binder containing TiO_2

Asphalt binder oxidizes due to temperature and weathering. A first approach was carried out considering the standard oxidation tests, Rolling Thin Film Oven Test (RTFOT) and Pressure Ageing Vessel (PAV) to assess aging on modified bitumen with nano-TiO_2. The modified asphalt binders showed improved the aging resistance. The next step will be the characterization of the binders by UV light oxidation.

5. Conclusions

This research aims to design a multifunctional recycled HMA for the surface layers. The recycled HMA were designed. The semiconductors materials are being mixed with other materials for doping. The asphalt binders with the capability to resist better to aging were designed. The next step of this research is the improvement of the doping, and the application of the nano/micromaterials by other techniques, for example, using resins or even electrostatic painting. The new capabilities and the essential characteristics will be evaluated.

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Study of Polyethylene Terephthalate (PET) Plastic Bottles in Threaded Form as Micro Level Reinforcement in Fly Ash Concrete

Manpreet Singh
Department of Civil Engineering
Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA)
dullat.mani@gmail.com

Abstract: The growing environmental concerns and proper disposal of construction and demolition waste is a challenge for construction industry. Now a day in our country Solid waste management is one of the major environmental concerns. A substantial growth in the consumption of plastic is observed all over the world in recent years. The use of demolition waste as a resource for recycling or recovery is gaining grounds in many countries. The proper selection and processing of demolition waste can be helpful in producing concrete. In construction industries, concrete masonry units are used commonly. The use of plastic bottles in construction materials has been around for the past twenty years, but with little focus on using threaded plastic bottles in the materials. This work aimed to justify use of threaded plastic bottles and fly ash in concrete. It also aims to investigate the strength of concrete when plastic bottles are used. Plastic bottles are increasingly becoming a menace to the environment due to the chemicals used in the manufacture, improper use and disposal. Waste plastic bottles are major cause of solid waste disposal. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse. As noted by Plastics Industry (2017) reusing plastic bottles may seem safe, but a chemical found in reusable plastic bottles, known as bisphenol A. (BPA) is suspected of posing a health risk to human beings. Hence, the safest way of disposing plastic bottles is to recycle them, particularly they can be used in the construction. The use of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. Plastic bottles are difficult to reuse, recycle and non-biodegradable and hence creates an environmental issue. A healthy and sustainable reuse of plastics offers a host of advantages. The suitability of recycled plastics as coarse aggregate in concrete and its advantages are discussed here. Due to ever increasing plastic pollution and construction waste pollution, it has become important to find a way for reducing such waste as it is hazardous to the environment. Plastic bottle is considered as a urban junk with sustainability characteristic which can be used as a material instead of some conventional material such as brick in building in construction. This paper intends to investigate the application of plastic bottles as one of the urban wastage in construction and that how it can lead to sustainable development. M25 design mix casted in which threaded plastic bottles filled with concrete made of using fly ash, coarse aggregates with plasticizer. Plastic bottles are cut into threaded forms. In due course of time, threaded plastic bottles evenly placing in layers into concrete cubes as micro level reinforcement. Later on its compressive strength, split tensile strength, flexural strength are tested. To overcome the above problems of over exploitation of

natural resources and environmental issue due to the use of non-biodegradable plastic bottles, attempt has been made to use threaded plastic bottles in concrete. Use of threaded plastic bottles will reduce environmental waste. Hence it also proves to be cost effective.

Keywords: M 25 concrete cubes, Threaded Plastic Bottles, Fly ash, Sand, Coarse aggregates, Ordinary Portland Cement (53 Grade)

USE OF BRICK DUST AND FLY ASH AS A REPLACEMENT OF FINE AGGREGATES IN SELF COMPACTING CONCRETE

Satgur Singh[1], Manpreet Singh[2]
[1,2]Department of Civil Engineering
Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA)
[1]Sidhu.sahaib@gmail.com
[2]dullat.ashman@gmail.com

Abstract: Self-compacting concrete principle is not new; special applications such as underwater concreting have always required concrete, which could be placed without the need for compaction. In such circumstances vibration was simply impossible. Early self- compacting concretes relied on very high contents of cement paste and, once supper plasticizers become available, they were added in the concrete mixes. The required specialized and well-controlled placing methods in order to avoid segregation, and the high contents of cement paste made them prone to shrinkage. The overall costs were very high and applications remained very limited. Compared to normal vibrated concrete (NVC), self-compacting concrete (SCC) possesses enhanced qualities and improves productivity and working conditions due to the elimination of compaction. SCC generally has higher powder content then NVC and thus it's necessary to replace some of the cement by additions to achieve an economical and durable concrete. Japan has used self-compacting concrete (SCC) in bridge, building and tunnel construction since the early 1990's. In the last five year, a number of SCC bridges have been constructed in Europe. In the United States, the application of SCC in highway bridge construction is very limited at very limited at this time. However, the USA precast concrete industry is beginning to apply the technology to architectural concrete. SCC has high potential for wider structural applications in highway bridge construction. The application of concrete without vibration in highway bridge construction is practically admissible. In the present study, attempt has been made to compare the mechanical properties of self-compacting and normal concrete specimens. The criteria used in it based on 7days, 28 days and 56 days compressive, splitting tensile and flexure strength and of conventional and self-compacting concrete for five Fly ash & Brick dust ratios as a replacement to fine aggregate.

Keywords: NVC; SCC; fly ash

Treatment of Underground Cavities Using Hybrid Cement Grout Mixes for Housing Suburb in North-West Part of Punjab State of INDIA

Satgur Singh[1], Manpreet Singh[2]
[1,2]Department of Civil Engineering
Swami Vivekanand Institute of Engineering & Technology, Banur (INDIA)
[1]Sidhu.sahaib@gmail.com
[2]dullat.ashman@gmail.com

Abstract: Expansive sinkholes appeared in a housing suburb in North-West part of Punjab in Republic of India which leads to prompting annihilation of properties and along these lines to halfway clearing of this local location. From completely led examination programs, the sinkholes were credited to the presence and spread of Karst cavities in the limestone bedrock layer. In consequence, an entire treatment program was adjusted to lessen the danger of sinkhole repeat by limiting the conceivable outcomes of crumple in the upper dimension holes inside the limestone bedrock. In this treatment, two distinctive concrete grout blends were planned and utilized for treatment of the Karst cavities; Cavity filling grout and penetration grout. The appraisal of the utilized blends included standard assessment of the compressive quality, droop, warm conductivity, warm obstruction, dying, and air content, loss of droop, stream and setting time. The treatment was trailed by an assessment program by penetrating control boreholes. A few centers of the solidified grout were extricated from the control boreholes and their properties were assessed and contrasted with those of research facility examples. This paper depicts distinctive sorts and blends of concrete grouts used in the ground treatment, components of value control program, and recurrence and kinds of tests. Appraisal of the outcomes notwithstanding outline of the venture is likewise introduced. The outcomes confirmed the productivity of the diverse bond grout blends utilized in this treatment.

Keywords: *Cement Grouts, North-west Part of Punjab, Sinkholes, Karst*

Use of TDR – Time Domain Reflectometry – for measuring moisture content in building walls

Teresa Stingl Freitas[1], Ana Sofia Guimarães[1], Vasco Peixoto de Freitas[1]

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

Abstract

Measuring moisture content in building materials is crucial for the correct diagnosis of buildings pathologies, for the adoption of appropriate intervention measures and for the efficiency evaluation of the treatment solutions applied. There are several different techniques available to measure the moisture content in building materials. However, it still remains a great challenge to perform those studies in building walls, especially in a minor-destructive way and with continuous moisture content measurements along the walls thickness. In this paper, the suitability of the TDR technique was tested on two limestone prototype walls. Each wall was equipped with four TDR probes, designed with the same length of the wall thickness. To overcome the difficulty pointed out by several authors to the use of TDR in hard materials, a steel auxiliary guide was developed. The preliminary results suggest that the TDR technique is suitable for moisture content monitoring in consolidated porous building materials.

Author Keywords. TDR, moisture content, minor-destructive technique, building walls.

Type: Oral Communication
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1. Introduction

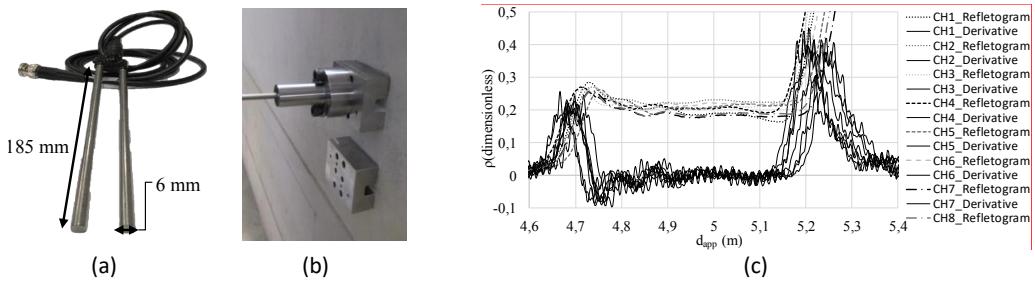
The TDR – Time Domain Reflectometry – technique is a widely used and accepted method for water content measurements in soils since 1980 (Topp, 1980). However, the development of the first experimental configurations suitable for its application in solid and hard materials only began to appear later. The difficulty to ensure a good contact between the TDR probe and the construction material under study, as well as the lack of suitable conversion empirical functions capable of providing the moisture content values from the direct results of the TDR measurements are additional obstacles for the application of the technique in building materials.

2. Basic principles

In TDR measurements an electromagnetic signal is propagated along the probe inserted into the material under test. Any impedance variations causes the partial reflection of the propagating signal. The direct output of a TDR measurement is a graphic called reflectogram, which displays the reflection coefficient, ρ, as a function of the apparent distance, d_{app} (Figure 1 c)). Changes in the moisture content of the study material affect the reflectograms. Whenever the moisture content increases, the greater is the apparent distance, d_{app} , and the lower is the reflection coefficient, ρ, allowing an indirect determination of the material's water content. The first derivative of the TDR reflectogram is used to easily identified impedance variations and in this way detect the portion of the reflectogram corresponding to the beginning and end of the probe (Cataldo, 2015).

3. Case study and preliminary results

The TDR measurements performed involved the use of: a TDR200 reflectometer, which generates a short rise time electromagnetic pulse, a Multiplexer that distribute a single electromagnetic pulse generated by the TDR200 unit by the different probes in use, eight two-rod TDR probes (Figure 1 a)) and finally an appropriate Labview-based software. Each limestone prototype wall with 200 mm thick was equipped with four TDR probes. To insert the TDR probes into the wall a steel auxiliary guide (Figure 1 b)) was developed and fixed to the surface of the wall during the drilling to assure parallel and appropriate spaces between the holes. Indeed, the presence of any air layer between the waveguide and the limestone will lead to variations in the moisture content measurements. The reflectograms and the corresponding first derivatives for all the eight channels (CH) are represented in Figure 1 c). Despite these preliminary results have been collected with the walls dry, they are really important to perceive the quality of the holes performed and to appreciate the contact between the rods and the limestone reached.



(a) (b) (c)

Figure 1: (a) Two-rod TDR probes; (b) steel auxiliary guide; (c) Reflectograms and corresponding first derivatives for the eight TDR probes installed in the two limestone walls.

4. Conclusions

The preliminary results obtained (Figure 1 c)) revealed that the development of the auxiliary steel guide made it possible to ensure a good contact between the TDR probe and the limestone, allowing to overcome one of the major obstacles to the applicability of the technique in hard materials. Indeed, the reflection coefficient, ρ, shows an almost constant value for all the eight probes installed meaning that no air layer is present next to the waveguides that could lead to variations in moisture content measurements. In the near future, a relationship between the reflection coefficient and the moisture content will be established. In this way, in opposition to the traditional local point sensors, each probe will provide several moisture content readings along the wall thickness.

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Understanding Construction waste from production perspectives

Mahmoud Karaz[1], Jose Texiera[2]

[1] Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Minho, Campus of Azurém, 4800-058 GUIMARAES, Portugal (krraz_09@yahoo.com) ORCID 0000-0003-3063- 4998

[2] Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Minho, Campus of Azurém, 4800-058 GUIMARAES, Portugal (jct@civil.uminho.pt) ORCID 0000-0001-6694- 4926

Abstract

Among the existing efficiency in construction industry waste is criticized for its negative environmental, economic and social impacts. However, the concept of waste has led to establish Toyota Production System (TPS) derivative lean production, which has been adapted to the construction. The understanding of lean principles within construction arenas has gain popularity, but the current practice still confronted with resulting waste in production. This paper holds a theoretical review to develop an understanding for the transformation of lean manufacturing into construction context. This research provides a conceptional framework for practitioners to adopt the synergies of Lean and BIM by applying the fundamental production theories.

Author Keywords. Waste, Lean Construction, Design, Production, Manufacturing.

Type: Oral Communication
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1. Introduction

Since manufacturing industry have underpinned the demand for eliminating waste from processes, the productivity has been increased through applying new philosophies in control systems, resulting in derivatives such as Lean manufacturing. The father of Toyota Production System (TPS), Ohno (1988) has determined the list of seven wastes (muda), in which comprises of (Overproduction, time on hand (idle), transportation, over processing, excessive inventory, unnecessary movement, and defects). Additionally, Ohno believed that the vicious circle of waste could be diminished, if they would hurdle overproduction, however in construction, Bølviken *et al.* (2014) have posed this list into construction production systems, as they assumed that the overproduction category is impractical due to peculiarities of construction. Thus, the category of overproduction in construction was replaced with making-do, task diminishment and buffering, those three phenomena are primary sources of waste.

Material waste constitutes negative impacts for economic, environmental and social entities in the construction, this kind of waste stands for the exceeded consumption of virgin materials and threatening to landfill locations. Research discussed both issues from production point of view on one hand, and from sustainability endeavors on other hand. This paper is structured to review the existing theory in construction production and how to relate them to waste management, second, understanding why manufacturing waste reduction more viable than in construction, and finally, an attempt to understand the effect of design stage on waste production.

2. Materials and methods

The research discusses the extant literature on areas including theoretical papers of waste reduction and lean construction. This because explained that an important this kind of review used to summarize and synthesize the findings and implications of research publications (Fellows; and Liu; 2015), in order to highlight the gap between ideal and actual practice. This review would provide an understanding framework for practitioners to determine appropriate lean design and construction tools to reduce specific waste sources.

3. Discussion

3.1. The underlying Theories for production

The fundamental theory in lean construction has been derived by Koskela (2000), namely, (transformation, flow, value) TFV theory, which streamlined construction processes into not only as transformation subprocesses, but also considered as the value creation to customer, and value interaction with flows of materials, equipment, information, and so on. The ideal Lean seeks to uninterrupted creation and transformation of value from raw status until final product or service (with assumption that downstream trades are customers for upstream), which called one-piece pull flow, this can be achieved by reductions in operation time including set-up, inspection, and processing time (Womack and Jones 2003). Thus, any interruption or loss of value is considered as waste. Minimizing waste requires reduction the amount of open spaces (Work in Process (WIP)), through exploiting the current active workspaces, and optimizing materials and equipment inventories (Little and Graves 2008). Another source of waste has been highlighted as the variation of handover between trade's or immaturity of tasks which generate unexcepted delays for upstream and downstream trade crews (Tommelein, Riley, and Howell 2002). Hence, deviations should be measured and systematically eliminated, which is a core principle of quality management and fulfills the theory of swift and even flow (Schmenner and Swink 1998).

3.2. Design stage contribution to construction waste

Production of information during design stage is the sole and most effective communication method concerning buildings. Clients and designers have different perspectives about the product, those different views may cause a misunderstanding in capturing the customer requirements. What's more, the conventional methods of construction management, push work toward site before conceptualizing the product and preparing requirements. Hence, designers could make decisions based on assumptions without considering waste in producing information, in order to start tasks on-site as soon as possible. Therefore, building based on those designs may cause conflicts between stakeholders due to functional failures, due to inflexible control systems for last minute client change and loss of information translation as a result of miscommunication.

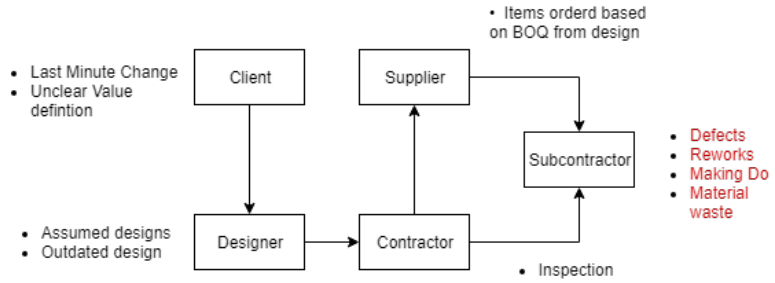

Figure1: *Waste in construction inherited from design stage adapted from (Koskela, Bølviken, and Rooke 2013)*

4. Conclusions

Theory advances the knowledge by communicating the discovered knowledge in the past into predicting and constructing the future of research (Webster and Watson 2002). This paper identified the concept of waste in construction from production point of view. Based on the findings, first, the underlying theories in manufacturing production and their derived list of waste have been tailored for construction use, due to peculiarities of construction projects including one-kind project, the interdependence between different kind of flows (Koskela, Bølviken, and Rooke 2013). Second, design processes have major effect on construction waste, there is a need to adopt common communication tools such as BIM, in order to eliminate causes of coordination, reworks and miscommunication (Eastman et al. 2011). Furthermore, from the review there is an evidence that lean construction is production management method seeks to optimize construction process and operations to add value for customer by capture their requirements, through investigating, controlling and minimizing waste. This research is ongoing doctoral research, is limited to theoretical and literature synthesizes which require solid framework to be tested and verified using quantitative and qualitative analysis.

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Development of hygrothermal accelerated ageing cycles

Joana Maia[1], Nuno Ramos[2], Rosário Veiga[3]
[1]CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (joanamaia@fe.up.pt) ORCID 0000-0001-5036-8581
[2]CONSTRUCT-LFC, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (nuno.ramos@fe.up.pt) 0000-0002-5331-7429
[3]LNEC, Av. Brasil, 101, 1700-066 LISBOA, Portugal, (rveiga@lnec.pt) ORCID 0000-0002-7135-8603

Abstract
The lack of durability assessment procedures directly applicable to thermal mortars motivated the development of durability assessment procedures. The combination of the analysis of existing procedures with hygrothermal simulation allowed the development of accelerated ageing hygrothermal cycles, applied to thermal rendering systems, taking into account the European climatic context, throughout a theoretical algorithm. The results contribute to the development of durability assessment methodologies directly applicable to thermal mortars.

Author Keywords. Thermal mortars, Durability, Accelerated ageing, Numerical simulation.

Type: Oral Communication
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1. Introduction

Durability of buildings could be affected by different factors like environmental agents and specific in-service conditions, but also by the materials properties (ABCB 2006). In general, it is difficult to simulate all the degradation mechanisms and the way they interact together. Although EN 998-1 (CEN 2010) provides a frame for thermal insulating mortars, the durability assessment of thermal mortars is not explored and no document refers to their application and evaluation as a multilayer system. Taking into account the identified gap, hygrothermal accelerated ageing cycles directly applicable to thermal rendering systems were developed.

2. Development of accelerated ageing cycles

The methodology for the development of accelerated ageing cycles adapted to thermal rendering systems, which replicate certain climate conditions, is presented. The methodology was developed taking into account: a) Climatic data: using existing climatic data files and "in situ" measurements; b) Existing standards: based on EN 1015-21 and ETAG 004; c) Preliminary degradation model: dynamic numerical simulation of the most representative degradation mechanisms by (Daniotti, Spagnolo, and Paolini 2008). The ageing cycle was developed through numerical simulation, using the hygrothermal simulation tool WUFI Pro. To maximize the temperature variation, the wall was modelled considering a high solar absorption coefficient (α=0.8) and the orientation with high solar radiation incidence (southwest orientation in the studied case). In addition, the rain incidence was not considered. The development of the heat-cold cycle results from an iteration process, until the achievement of the defined requirements – $T_{cycle} \approx T_{real}$ –, considering 1st and 99th percentile, as shown in Figure 1-a). Through the development of a theoretical methodology (see Figure 1-b), based on the previous developed heat-cold cycle, it is possible to define specific heat-cold cycles representative of specific European climates, by Formulas 1 and 2.

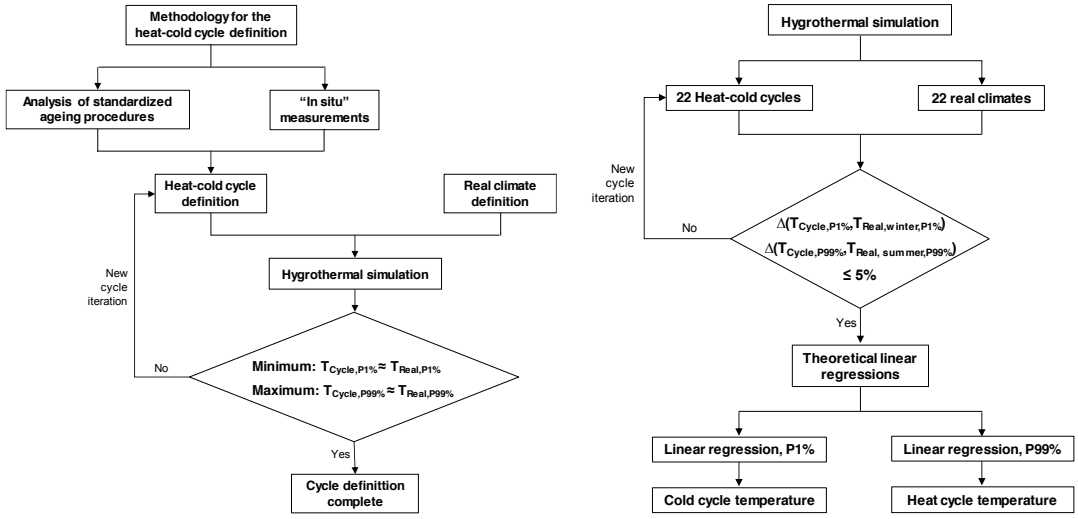

Figure 1: Development of heat cold cycles: a) Methodology; b) Theoretical algorithm applicable to European climates.

$$T_{cycle}(cold) = 1.2855 \times T_{e,P1\%} - 8.2364 \quad (1)$$

$$T_{cycle}(heat) = 0.8627 \times T_{e,P99\%} + 37.562 \quad (2)$$

3. Conclusions

The heat-cold cycle development enabled developing and optimizing a theoretical algorithm regarding the heating and the cooling periods allowed the direct determination of the heat and cold cycle temperatures, based on the exterior air temperature of each climate. This fact contributes for the definition of durability assessment methodologies applicable to thermal mortars and related systems.

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A proposal for usability assessment of visual immersive systems for Civil Engineering Education

Fábio Dinis[1], João Poças Martins[2], Fernanda Sousa[3], Bárbara Rangel[4], Ana Sofia Guimarães[5]

[1]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (fabio.dinis.miec@gmail.com) ORCID 0000-0003-4017-7962

2Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (jppm@fe.up.pt) ORCID 0000-0001-9878-3792

[3]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (fcsousa@fe.up.pt) ORCID 0000-0001-8428-7704

[4]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (brangel@gcloud.fe.up.pt) ORCID 0000-0002-5911-9423

[5]Departmento de Engenharia Civil, Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, 4200-465 PORTO, Portugal (anasofia@fe.up.pt) ORCID 0000-0002-8467-6264

Abstract

Human-computer interactions in the AECO sector may be improved through alternative approaches such as the implementation of immersive applications (Meža, Turk, and Dolenc 2015; Paes, Arantes, and Irizarry 2017; de Klerk et al. 2019). However, there is a lack of common frameworks and procedures to assess the usability issues that may arise from the application of such immersive systems (e.g., Virtual Reality (VR), Augmented Reality (AR)). Thus, the present work proposes a methodology and guidelines to conduct usability assessments for Civil Engineering Education.

Principal Component Analysis (PCA), a multivariate data analysis methodology, was used to ascertain the possibility of reducing the dimensionality of the problem (usability attributes), *i.e.*, to find a few set of new variables, denominated principal components, able to well explain the correlations between the original observed variables in terms of their correlations with a smaller set of new variables.

Results confirm that the initial set of variables is hardly replaced by a smaller number of principal components, hence lacking a sufficiently strong relation. Furthermore, the authors suggest presenting univariate and bivariate measures to be able to establish future comparisons relating these attributes and other immersive systems.

Author Keywords. Civil Engineering Education, Usability, Immersive, Assessment, Virtual Reality, Augmented Reality.

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Core sustainability indicators for future-proofing and monitoring of the economic and environmental life cycle performance of buildings

Rodrigo Dourado[1], Nuno Almeida[2], Filipa Salvado[3], Ricardo Teixeira[4], Álvaro Azevedo[5]

[1]Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (rodrigo_dourado@hotmail.com)

[2]Department of Civil Engineering, Architecture and Georesources, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (nunomarquesalmeida@tecnico.ulisboa.pt) ORCID 0000-0003-1970-4553

[3]Nacional Laboratory of Civil Engineering (LNEC), Av. do Brasil 101, 1700-066 Lisboa, Portugal (asalvado@lnec.pt)

[4] Laboratory of Robotics and Engineering Systems (LARSyS), Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal (ricardo.teixeira@tecnico.ulisboa.pt) ORCID 0000-0003-3451-0458

[5]Nacional Laboratory of Civil Engineering (LNEC), Av. do Brasil 101, 1700-066 Lisboa, Portugal (ava@lnec.pt)

Abstract

The investment on building projects considerably mobilizes both financial and environmental resources during long timespans. It is increasingly important for the Architecture, Engineering and Construction (AEC) practitioners to justify both the capital investments in this type of projects and the subsequent expenditures over the years. But the information relating to the economic and environmental performance of buildings assets over their life cycle is not readily available nor properly organized (Anand & Amor 2017; Salvado et. al 2018). This study aims at overcoming this significant limitation and facilitate the widespread incorporation of economic and environmental information into the decision-making processes of the AEC sector, namely in procurement environments.

This study seeks to establish an indicator-based joint approach for future-proofing and monitoring the economic and environmental life cycle performance of building projects. It builds upon previous experience in setting combined conceptual frameworks within the construction sector (Salvado et. al 2018; Almeida et. al 2015) and seeks to facilitate compliance against requirements of relevant international and European standards (e.g. ISO 41000, ISO 55000, ISO 21929-2, ISO 15686-5, EN 15643, EN 15221) and applicable regulations (e.g. European Directive 2014/24/EU), plus the incorporation of state-of-the art developments in the fields of Building Management, Life Cycle Costing and Life Cycle Assessment. The proposed topic is transdisciplinary and involves complementary background knowledge on civil engineering, environmental sciences, data management, industrial ecology and economics.

The method of this study is as follows: i) literature review and gap analysis towards integrating the economic and environmental information of buildings throughout their life cycle; ii) establishment of core economic and environmental sustainability indicators for the AEC sector on the life cycle performance of building assets and asset systems; and iii) development of databases that feed the set of indicators for specific types of building projects.

Author Keywords. Indicators, economic performance, environmental performance, life cycle, building projects, construction.

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A SYSTEMATIC REVIEW BASED ON THE BIBLIOMETRICS INDEXES FOR DEVELOPING A RESEARCH TOPIC

Andréa R. Souza[1], Ana Sofia M. S. Guimarães[2], Nuno M. M. Ramos[3]
[1]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (andrearesende.s@gmail.com) ORCID 0000-0001-6575-2527
[2]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (anasofia@fe.up.pt) ORCID 0000-0002-8467-6264
[3]CONSTRUCT-LFC. Faculty of Engineering of Porto, Roberto Frias, 4200-465 PORTO, Portugal (nmmr@fe.up.pt) ORCID 0000-0002-5331-7429

Abstract

Despite the increasing availability of information in digital databases of scientific articles, in most cases, this information needs to be systematised, since they are currently carried out by a narrative or "convenience" method. The present meta-analysis proposes an observation of the possible universe for the research of the subject, based on the concept that the researcher is new in the area, that needs to develop ability in the analysis of magazines, authors and even of concepts, not being based only on assumptions already made. The proposed methodology proved to be effective in delimiting a spectrum of research, limiting the initial search for articles relevant to the study of art.

Author Keywords. Research methodology, Systematic review, State of the art, Bibliometric index.

Type: Oral Communcation
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1. Introduction

It is necessary to avoid epistemology to rely only on information from a particular group of researchers, who share a standard set of close subjects, concepts, and common-purpose issues, thus always creating a closed cycle of publishable relationships(Santamouris, Synnefa, and Karlessi 2011). The objective of this article is to produce a methodology for the development of state of the art, applying a systematic review, which can be replicable.

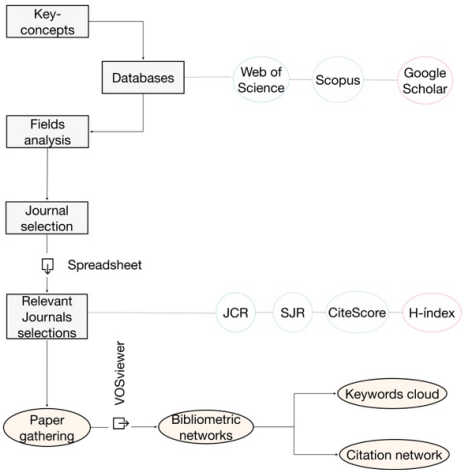
2. Development of the systematic bibliometric methodology

The systematic bibliometric review proposed has seven steps that begin with the key-concepts choice and ended with the determination of the keyword cloud and authors most cited for the research field. The flowchart for methodology applied can be visualised in Figure 1.

For the diagnostic a data tabulation program and another for the construction of a bibliographic network, in this case, VOSviwer should be used. Many studies took into considering to result in **Table 1** (Okagbue et al. 2018).

Index	Reference Value
JIF	2.80
H-index	37.00
JSR	1.60
CiteScore	1.50

Table 1: Bibliometric reference indexes.



Step 1 Key-concepts: Election at least two key-concepts related with the topic research;

Step 2 Databases: Election of the scientific database;

Step 3 Fields analysis: Determinate by the chose database the relevant research area (at least 3);

Step 4 Journal selection: relate the journal for each area (at least 20 for the area);

Step 5: Selected the relevant journals considering the bibliometric index rank Table 1;

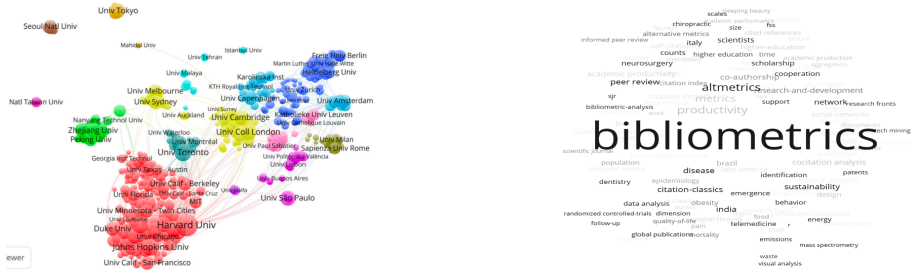
Step 6: Selected gathering the papers of the relevant journals that have the key-concepts;

Step 7: Construct the bibliometric network.

Figure 1: Flowchart of the systematic bibliographic review.

3. Discussions

The proposed methodology results in the most cited authors Figure 2 (a) and at the most used keywords cloud Figure 2 (b).



(a) (b)

Figure 2: Results of the methodology. (a) Bibliometric network. (b) Keywords cloud.

4. Conclusions

The present article motivated by the search for new systematic reviews in the area of engineering, especially the civil one, presented an appropriate routine for the meta-analysis of the study of the art, with the definition of the importance of the authors and keywords.

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