

## PREFACE

This book contains the abstracts of the papers presented in the 7<sup>th</sup> International Conference on Safety and Durability of Structures (ICOSADOS 2016), held in the University of Trás-os-Montes e Alto Douro (UTAD), city of Vila Real, Portugal, from 10<sup>th</sup> to 12<sup>th</sup> of May 2016.

A contribution in the internationalisation goal of ICOSADOS was achieved with this event taking into account that authors or members of the Scientific Committee of eight countries collaborated. These countries are Poland, Latvia, Portugal, UK, Italy, Mexico, France and Brazil.

There was also a significant participation of the industry which sponsored the conference and gave an important contribution for its success. The Civil Engineering students of UTAD also gave a relevant help in the organization of this conference.

In this conference there were four lectures presented by keynote speakers who are international references in the topics of safety and durability of structures. These keynote speakers are Professors Pawel Sniady (Wrocław University of Environmental and Life Sciences, Poland), Ulvis Skadins (Latvia University of Agriculture, Latvia), Jitendra Agarwal (University of Bristol, United Kingdom) and António Arêde (Engineering Faculty of University of Porto, Portugal).

The conference scope includes a wide range of safety and durability of structures topics such as:

- S1 - Degradation: diagnostics and evaluation methods
- S2 - Structural, physical and material characterisation
- S3 - Numerical modelling
- S4 - Natural and man-made risks
- S5 - Requirements and code provisions
- S6 - Assessment, conservation, repair and strengthening
- S7 - Case studies

The Editors are grateful to all authors, members of the scientific committee and other colleagues that make possible the publication of this book.

The Editors  
Vila Real  
2016



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**THERMAL MODEL FOR CHARRING RATE CALCULATION IN WOODEN  
CELLULAR SLABS UNDER FIRE**

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**ABSTRACT**

Wood is a natural and traditional building material, as popular today as ever, and presents advantages. Physically, wood is strong and stiff, but compared with other materials like steel is light and flexible. Wood material can absorb sound very effectively and it is a relatively good heat insulator. But dry wood burns quite easily and produces a great deal of heat energy. The main disadvantage is the high level of combustion when exposed to fire, where the point at which it catches fire is from 200–400°C. After fire exposure, is need to determine if the charred wooden structures are safe for future use. Design methods require the use of computer modelling to predict the fire exposure and the capacity of structures to resist those action. Also, large or small scale experimental tests are necessary to calibrate and verify the numerical models. The thermal model is essential for wood structures exposed to fire, because predicts the charring rate as a function of fire exposure. The charring rate calculation of most structural wood elements allows simple calculations, but is more complicated for situations where the fire exposure is non-standard and in wood elements protected with other materials.

In this work, the authors present different case studies using numerical models, that will help professionals analysing woods elements and the type of information needed to decide whether the charred structures are adequate or not to use. Different thermal models representing wooden cellular slabs, used in building construction for ceiling or flooring compartments, will be analysed and submitted to different fire scenarios (with the standard fire curve exposure). The same numerical models, considering insulation material inside the wooden cellular slabs, will be tested to compare and determine the fire time resistance and the charring rate calculation.

## Introduction

The wooden slabs are typical panels applied in building structures with a rustic and decorative look. The combination between the wood materials and other acoustic material layers offers aesthetics and sound absorption effect. Also, perforations in these slabs are common and available in different patterns and sizes. The applications of wooden slabs are typical in auditoriums, offices, restaurants, concert halls, schools, hotels, gymnasiums, etc. Fire tests in different wood elements were performed by Frangi et al. [1], verifying the effect of perforated acoustic layer according different thickness and enlarging the experimental background of wood slabs in fire predicting simplified calculation models.

Wood is a thermally degradable and combustible material, when subjected to the developing fire produces a surrounding charring depth layer, with no mechanical resistance, resulting a reduced cross-section. The charring rate is an important factor in the fire design of exposed wooden elements, due the determination of how quickly the size element decreases to a non-safe level [2]. In many applications the thermal degradation and fire performance of wood can be critical. In building applications fire performance of wood are regulated and based on standard tests [3]. Several researchers have presented experimental models and analytical methods to calculate the physical degradation of wood due high temperatures, [2, 3, 4]. The charring rate of different wood species when exposed to fire conditions has been studied by others researchers [3, 5 to 14] using empirical models or performed different fire tests.

In perforated cellular wooden slabs, the size of perforations facilitates and increase the heat flow and flames penetration over the slab. The constructive elements should be designed in accordance, to prevent and delay the fire damage effect, allowing that the slab could remain in service for long time with safety and durability.

An insulation material in combination with other building materials allows to reduce the heat transfer inside the cavities. There are many kinds of insulating materials, each of which has its own set of advantages and disadvantages, and none of which are the perfect solution. The best insulation materials should have the lowest thermal conductivity, in order to reduce the total coefficient of heat transmission. The insulation material should be rated as non-flammable and non-explosive. When the insulation material burns, the products of combustion should not introduce toxic hazards according all safety procedures in use. They may be categorized by its composition (natural or synthetic materials), form (spray foam, panels...), structural effect, functional mode, resistance to heat transfer, environmental impacts, etc. The choice of which insulation material is used depends on a wide variety of factors: thermal conductivity, moisture, strength, ease of installation, durability, cost, toxicity, flammability, also environmental impact and sustainability. There are different insulation materials: mineral wool, ceramic fibre, calcium silicate boards, gypsum boards, intumescent materials, spray-on cement based materials. Depending of the application or the conjunction with others materials, the choose of the insulation material will be the guarantee that produces the better behaviour and durability of the involved structure.

This work presents ten different 2D numerical simulations, to predict the time-temperature history and the charring rate calculation during a fire scenario in wooden cellular slabs (with rectangular or circular perforations), according two different geometries. Two different insulation material (Medium Density Fiberboard MDF or Mineral wool RW) with different sizes (18mm or 36mm) will be added inside the perforated cavities to determine the behaviour of the temperature evolution. This study is according to others investigations developed by the authors of this work [15 to 18].

## Materials Properties and Fire Curve

The most important factors for the resistance in wooden elements submitted to fire are the material properties degradation and the charring depth formation. The wood density decreases with the material degradation caused by the pyrolysis process, in the presence of high temperatures. Wood temperatures around 280°C to 300°C are generally prescribed as the start of pyrolysis, the wood burns leading to material degradation and its decomposition. The wood thermal properties are strongly affected by temperature and moisture content levels, well documented in Eurocode 5 [19]. Fig. 1 provides the design values for wood thermal properties, for density, thermal conductivity and specific heat, according Eurocode 5 [19]. The specie (Spruce) considered in this study presents a value of density equal to 450 kg/m<sup>3</sup>. The wooden cellular slabs in study have three different cavities, and the internal cavities will be filled with air. Fig. 2 gives the thermal properties of the air with temperature dependence for specific heat, thermal conductivity and density, [20].

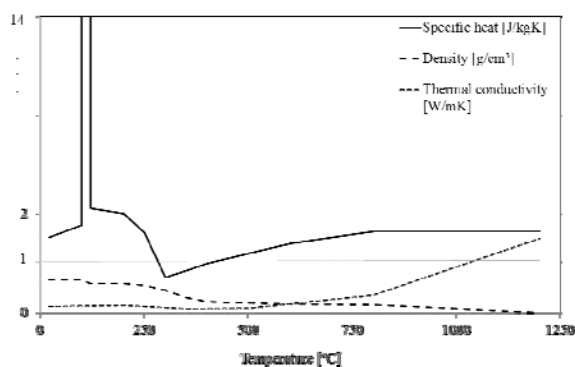


Figure 1: Thermal properties of wood.

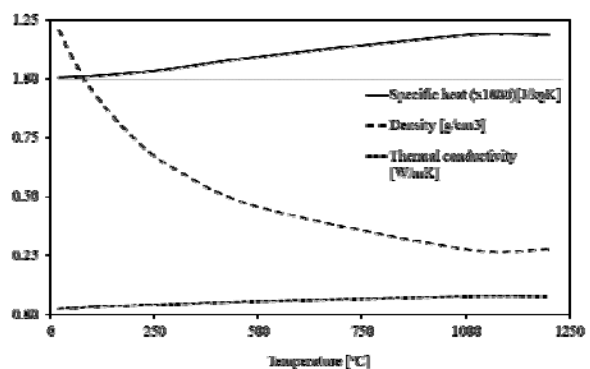


Figure 2: Thermal properties of air.

The insulation materials considered in this work are the medium density fibreboard (MDF) and Mineral wool (RW). MDF is a wood-based panel composed by fibres that are mixed with resin and pressed into flat panels under high temperature and pressure. Typical applications of MDF are furniture, laminate flooring, decorative mouldings, office dividers, walls and ceilings, house construction, sliding doors, kitchen worktops, interior signage, and other industrial products. The production of this material is increasing due to the development of manufacturing technologies. Nevertheless, MDF material is combustible and the level of fire resistance depends of their density. The MDF considered in the present study has properties according ISO 10456 [21] and EN316 [22]. Mineral wool (RW) is a general name for fibre insulation materials that are formed by spinning or synthetic minerals. The RW material contributes to energy efficient, good acoustics, comfortable indoor climate and fire safe buildings, non-combustible with a melting point approximately equal to 1177°C, [23].

Proper selection of the insulating materials is based on the thermal properties which include the density, low thermal conductivity and high specific heat. Also a lower thermal diffusivity leads to a good thermal insulation [24]. This parameter determines the temperature distribution in non-steady or transient conditions and measures the ability of a material to transmit a thermal disturbance, indicating how quickly a material's temperature will change. Also all thermal properties are function of temperature, porosity, density and particle sizes.

Table 1 represents the thermal properties for different insulation materials, including the MDF and RW used in this work. The calculation of the thermal diffusivity permits to conclude that the better are MDF and gypsum board, but both are combustibles.

According to this situation and verifying the combination with wooden slab, MDF and RW were considered in this study.

Table 1. Thermal properties for insulation materials

Insulation Material	Density $\rho$ , kg/m <sup>3</sup>	Thermal conductivity $\lambda$ , W/mK	Specific heat $c_p$ , J/kgK	Thermal diffusivity $\alpha = \lambda / (\rho c_p)$ , $\times 10^{-7}$ m <sup>2</sup> /s
Medium density fibreboard, MDF (combustible)	600	0.140	1700	1.37
Mineral fibre, RW (no combustible)	100	0.040	840	4.76
Glass fibre, (no combustible)	30	0.034	960	14.60
Gypsum board, (combustible)	1442	0.170	1090	1.08

In the numerical simulation, the evolution of fire temperature ( $\theta$  in °C) over time ( $t$  in min) was defined by standard fire curve ISO834, according to Eq. 1, Eurocode 1 [25]:

$$\theta_{\infty} = 20 + 345 \log_{10}(8t + 1) \quad (1)$$

### Numerical Wooden Cellular Slabs

The model of wooden cellular slab is based on the dimensions of a constructive solution tested in laboratory [17, 18]. In this work only the two-dimensional (2D) slab cross-section with perforations was considered for analysis. Three different cellular zones were considered (two with perforations and one without perforations). The wooden cellular slab has different types of perforations (rectangular R or circular D) at the bottom, as represented in Fig. 3.

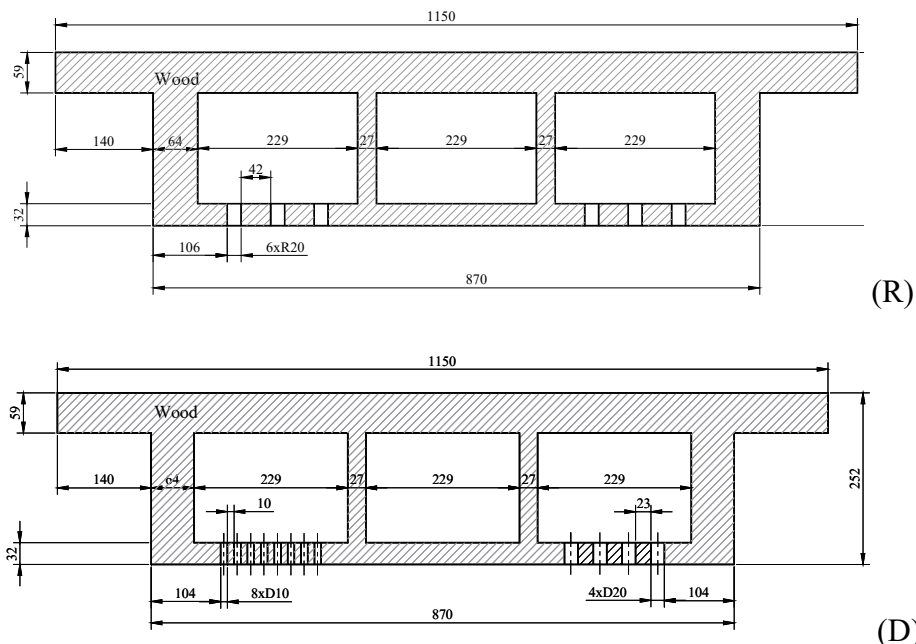


Figure 3: Wooden cellular slab: rectangular (R) and circular (D) perforations.

Additional 2D models will be considered with internal insulation material (MDF and RW). The MDF and RW were added inside the perforated cavities and considered with

different sizes (18mm or 36mm). Due the combination between materials and slab geometries, ten numerical models were solved. For each model, one side was considered to fire scenario and the time-temperature history was obtained during one half hour of fire exposure.

A 2D finite element (Plane77) with 8 nodes was used for thermal and nonlinear material in transient analysis, using Ansys program. In order to fully satisfy the nonlinear conditions of the numerical problem, an iterative procedure in each time step it is necessary to employ. In Ansys a modified Newton-Raphson method was adopted to solve the nonlinear problem, and the time interval considered for each step was equal to 10s.

The bottom surface of the wooden slab was exposed to standard fire curve [25] during 1800s. The temperature on the internal cavities follows real heating curves obtained during experimental tests [17, 18] and measured with plate thermocouples. The convection coefficient is taken equal to  $25\text{W/m}^2\text{K}$  [25] inside cavities and in the exposed surface. At the unexposed surface the room temperature ( $20^\circ\text{C}$ ) is applied and the value of convection coefficient is equal to  $4\text{W/m}^2\text{K}$ . The emissivity of the flames is taken equal to 1,0 for exposed side and internal cavities [25]. When insulation material is considered the adjacent cellular zones were filled with air.

Fig. 4 represents the temperature at one side fire exposure (bottom surface) of the cellular wood slab with and without insulation at the end of 1800s and the correspondent mesh model. The physical behaviour of the wooden slab is conditioned by the char layer formation. These phenomena are considered in the numerical model according the criterion of char layer applied by the isothermal of  $300^\circ\text{C}$  Eurocode 5 [19]. The results represent the charring layer on the wood material, in grey colour. There are typical values for charring rate of wood between 0.5-1.0mm/min. Eurocode 5 [19] suggests a charring rate equal to 0.65mm/min for solid wood with density greater than  $290\text{kg/m}^3$ . The evaluation of the char layer thickness, depends on the exposed time and determines the charring rate in mm/min. To measure the char layer thickness in each slab, different measurements were performed in different locations in the numerical model.

The numerical results of charring rate in cell without perforations have similar behaviour in all tested wooden slabs with a mean value equal to 0.71mm/min. The behaviour of cells with perforations are different, all cross sections suffers high level of char due fire. At the last time instant of exposure fire the cells with perforations don't have any residual cross section. In cell with small circular perforations the physical degradation starts first when compared with rectangular and higher circular perforations.

The use of insulation material increases the fire resistance and the safety of the wooden slab, with no flames propagation for inside the cavities. Nevertheless, RW material offers high resistance values of temperatures for starts the physical degradation ( $1177^\circ\text{C}$ ), and the heat inside cavity increases due the value of thermal diffusivity. MDF only resists until  $300^\circ\text{C}$ , nevertheless the heat inside cavity is lower due the thermal diffusivity for this material. Two different thickness of insulation material were used. During the fire exposure RW material resists without any degradation and more durability. MDF only resists when a board thickness is equal to 36mm in the model with rectangular perforations.

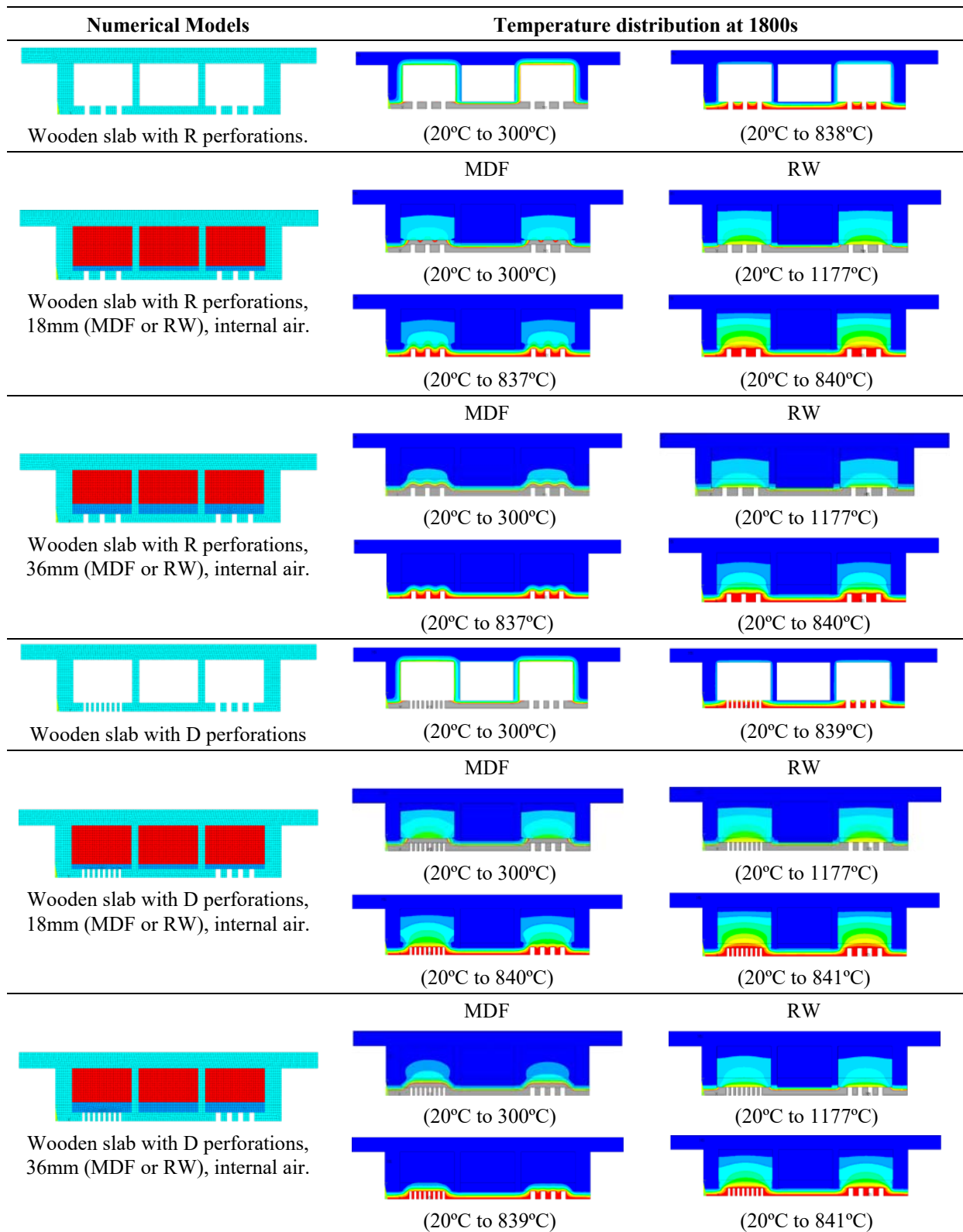


Figure 4: Numerical results of temperature distribution in all models.

## Conclusions

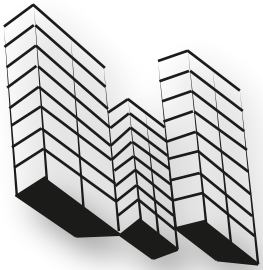
Wood material when exposed to fire presents a thermal physical degradation. In wooden slab with perforations, the type and the size of perforation can limit the use of these constructive elements in terms of fire resistance. The time-temperature history inside the cellular zones was also characterized and the shape and size of perforations could be compared with the unperforated cell. These constructive elements should be chosen before, to prevent and delay the fire damage effect, allowing that the slab could remain in service with more safety and durability. Different material insulation could be used in addition to guarantee more durability in these type of elements.

The developed numerical model allows future studies and simultaneously characterizes the effect of perforations in wooden slabs including additional insulation materials to minimize the fire risk. The numerical model can easily be adjusted for other constructive solutions, in buildings with several wood floors and slabs assemblies. This type of analysis is important in safety and structural design because it determines how quickly the wood cross-section size decreases to a critical level at high temperatures and what is the level of fire resistance.

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**ICOSADOS 2016**

**7<sup>th</sup> INTERNATIONAL CONFERENCE  
ON SAFETY AND DURABILITY OF STRUCTURES**

**10<sup>th</sup> - 12<sup>th</sup> May 2016**

**Universidade de Trás-os-Montes e Alto Douro  
Vila Real | Portugal**

**FINAL PROGRAMME**

7<sup>th</sup> International Conference on Safety and Durability of  
Structures  
ICOSADOS 2016  
May 10 - 12, 2016, UTAD, Portugal

Final Program



# ABOUT THE CONFERENCE

The 7th International Conference on Safety and Durability of Structures - ICOSADOS 2016 is an event which its extended scope enables scientific discussion on safety and durability of buildings, water engineering and other infrastructures. The conference integrates various sectors of construction professionals: engineers, architects, designers, technicians, contractors, researchers and students. This creates the opportunity to present actual problems and solutions from these domains based on scientific research and application of modern technologies and materials and diagnostic methods.

The conference scope includes a wide range of safety and durability of structures topics such as:

- S1 - Degradation: diagnostics and evaluation methods
- S2 - Structural, physical and material characterisation
- S3 - Numerical modelling
- S4 - Natural and man-made risks
- S5 - Requirements and code provisions
- S6 - Assessment, conservation, repair and strengthening
- S7 - Case studies

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# CONFERENCE VENUE

The Conference will be held at Edifício de Ciências Florestais, of the University of Trás-os-Montes e Alto Douro (UTAD). UTAD is located in the north-eastern city of Vila Real, near the Douro Valley Region (UNESCO World Heritage Site, since 2001) of Portugal.



- Built-up area
- Green spaces
- Agricultural land
- Escarpments (ecological reserve)

- 7 Venue
- 31 Conference Restaurant
- 32 Entrance to the Campus

# PROGRAM

## Tuesday (10th May)

**09:00-17:30**

Registration

**10:30-11:00**

Opening ceremony (auditorium)

António Fontainhas Fernandes,  
Rector of the University of Trás-os-Montes e Alto Douro, Portugal  
Rui Santos,  
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University of Trás-os-Montes e Alto Douro, Portugal

**11.00- 1.15**

Musical Moment - Conservatório Regional de Música de Vila Real

**11:15-11:30**

Coffee Break

**11:30-12:30**

Keynote Speakers (auditorium)  
Chairman: Anabela Paiva

Professor Pawel Sniady (Wrocław University of Environmental and Life Sciences, Poland)  
Presentation title:

*Reliability of structure with respect to capacity degradation with time*

Professor Ulvis Skadins (Latvia University of Agriculture, Latvia)

Presentation title:

*Human Error and Safety of Structures: Challenges and Possibilities for Universities*

**12:30-14:30**

Lunch

**14:30-16:00**

Parallel Session 1 (auditorium)

Scope 1 - Degradation: diagnostics and evaluation methods

Chairmen: Sofia Ribeiro and Isabel Bentes

**S1.01**

*Anomaly diagnosis in ceramic claddings by thermography – a review*

Tomás Lourenço, Luís Matias and Paulina Faria

**S1.02**

*Influence of defects on reliability of reinforced concrete retaining wall*

Rytis Skominas, Vincas Gurskis, Raimondas Sadzevicius and Dainius Ramukevicius

**S6.11**

*Features of technological process in the dome design restoration of orthodox churches*

Dmytro Goncharenko, Jaan Miljan and Viktoriia Lykhohrai

**S6.06**

*Influence of impact strength for possibility of usage and repair of steel structures*

Kamil Pawłowski and Agata Włóka

**S1.05**

*Inspection techniques into special structures*

Maria Ferreira and Cristina Reis

**S2.12**

*CFRP fire behaviour – passive fire protection materials*  
Débora Ferreira, Luís Duarte, Luís Mesquita and Paulo Piloto

**14:30-16:00** Parallel Session 2 (room F2.17)  
Scope 1 - Degradation: diagnostics and evaluation methods  
Chairmen: Jaan Miljan and Jorge Pinto

- ST.01** *Trimble Structures Division*  
Emilia Cabral
- ST.02** FIBRANxps – Energy Shield (The insulation that protects all your building)  
Vera Silva
- S4.04** *Waste water purifying after car wash*  
Arta Usejonoka
- S6.08** *Renovation of kindergarten buildings in Brno*  
Anabela Gonçalves Correia de Paiva, Jitka Mohelnikova Jiři Hirš, Pavla Mocova
- S1.10** *Damages of small building objects as a result of inspection and maintenance omissions*  
Andrzej Pawłowski

**16:00-16:30** Coffee Break

**16:30-18:00** Session 3 (auditorium)  
Scope 2 - Structural, physical and material characterisation  
Chairmen: Débora Ferreira and Ana Sá

- S1.07** *Chloride assessment in structures. Influences of sampling and test location*  
M. S. Ribeiro, João Lage and A. Gonçalves
- S2.01** *Ultra-high durable concrete: a way towards safe and durable structures*  
Iman Ferdosian and Aires Camões
- S1.04** *Chloride penetration into carbonated concrete*  
Raphaelle Malheiro, Aires Camões, Gibson Meira, Rui M. Ferreira, Maria T. Amorim and Rui Reis

- S2.04** *Fatigue behaviour of old masonry arch bridges*  
Michelangelo Laterza, Michele D'Amato and Vito  
Michele Casamassima
- S2.10** *Water absorbing geocomposite influence on root  
systems of plants used in geotechnical bioengineering*  
Andrzej Pawłowski, Krzysztof Lejcuś, Jolanta  
Dąbrowska, Daniel Garlikowski and Michał Śpitalniak
- S2.18** *Assessment of timber-steel connection in terms of  
correct design and construction - preliminary tests*  
Maciej Andrzej Orzechowski and Radosław Tatko
- S3.03** *The influence of the level of geometrical idealization  
on static response of the structure by example of  
timber truss of the roof of medieval church*  
Radosław Tatko and Maciej Andrzej Orzechowski
- 19:00** Welcome Drink (at the Vila Real Town Hall)

## Wednesday (11th May)

**09:00-11:00**

Session 4 (auditorium)  
Scope 2 - Structural, physical and material  
characterisation  
Chairmen: Andrzej Pawłowski and Sandra Pereira

- S2.02**      *Durability analysis of RC sewer after long time service*  
Maciej Yan Minch and Andrzej Kmita
- S2.13**      *An attempt to identify the bonding between concrete layers in existing elements using non-destructive testing methods and the ANN*  
Jerzy Hola, Lukasz Sadowski and Slawomir Czarnecki
- S1.09**      *Ductility and durability of strain hardening cementitious composites in the marine environment*  
Bárbara Ferreira, Eduardo Pereira, Vítor Cunha and João Almeida
- S2.15**      *Tensile strain hardening of a metakaolin-based fibre reinforced composite*  
Bárbara Ferreira, Eduardo Pereira, Vítor Cunha, João Almeida, Edgar Soares, Nuno Cristelo and Tiago Miranda
- S2.16**      *Improvement of safety and durability of foam gypsum acoustic plate by using multilayered board*  
Kristaps Pulkis, Santa Soloveiko, Raitis Brencis and Juris Skujans
- S2.17**      *Analysis of construction steel creep at fire temperatures*  
Agata Włóka, Kamil Pawłowski and Robert Świerzko
- S2.19**      *Test results and theoretical study of moment resisting connections*  
Edgars Zeltiņš and Jānis Kreilis

**S4.01** *Slopes stability of hydrotechnical earth structures in the conditions of rapid water level changes*  
Zofia Zięba, Kinga Witek and Michał Molenda

**S4.02** *Evaluation of design solutions applied on the modernised section of odra river embankment in the exploitation conditions of the malczyce barrage*  
Zofia Zięba, Kinga Witek and Mateusz Młynarczyk

**11:00-11:30** Coffee Break

**11:30-12:30** Keynote Speakers (auditorium)  
Chairman: Jorge Pinto

Professor Jitendra Agarwal (University of Bristol, UK)

Presentation title:

*From reliability to resilience of structures and infrastructures*

Professor António Arêde (Faculty of Engineering of University of Porto, Portugal)

Presentation title:

*Traditional buildings built with masonry walls: structural behaviour and strengthening solutions*

**12:30-14:30** Lunch

**14:30-18:00** Technical Visit

**20:00** Conference Dinner - Quinta do Paço

## Thursday (12th May)

**9:00-11:00**

Session 5 (auditorium)  
Scope 3 - Numerical modelling  
Chairmen: Ulvis Skadins and Cristina Matos

**S3.01**

*Application of finite difference method in dynamics of multi-span bridge girders subjected to various types of moving load*  
Filip Zakes and Pawel Sniady

**S3.02**

*Finite element modelling and sensitivity of traditional Portuguese adobe masonry*  
Fulvio Parisi, Claudio Balestrieri and Humberto Varum

**S3.04**

*Computational fluid dynamics analysis on influence of the roughness of vertical elements in flow behaviour*  
Adelaide Ajú, Serafim Pinto, Hugo Canilho, João Alves and Cristina Fael

**S3.05**

*Evaluation of the seismic vulnerability of a RC building considering the masonry infill walls out-of-plane behaviour – numerical study*  
André Furtado, Hugo Rodrigues, António Arêde and Humberto Varum

**S3.06**

*Vulnerability assessment of real water-world distribution networks using the TV EPN informatics tool*  
António Duarte, Diogo Sousa, João Varejão, Jorge Pinto and Isabel Bentes

**S4.03**

*The effectiveness of retention bowls*  
Tiago Borges, Cristina Reis, Rui Couto, Paula Silva and Carlos Oliveira

**11:00-11:30**

Coffee Break

<b>11:30-12:30</b>	<p>Session 6 (auditorium)  Scope 6 - Assessment, conservation, repair and strengthening  Chairmen: Silvija Strausa and Fernanda Rodrigues</p>
<b>S5.01</b>	<p><i>Local crushing of concrete walls according to Eurocodes and former Latvian building norms</i>  Ulvis Skadiņš</p>
<b>S6.01</b>	<p><i>Impact of skylight thermal properties on the overall energy efficiency of sustainable buildings</i>  Sandra Gusta, Silvija Strausa and Inese Ozola</p>
<b>S6.03</b>	<p><i>A simplified procedure for risk assessment of cultural heritage: definition and application to religious architecture</i>  Michelangelo Laterza, Michele D'Amato and Daniela Diaz Fuentes</p>
<b>S6.04</b>	<p><i>Development of retrofitting solutions: "Bridge" repair cracking technique - experimental campaign</i>  Manuel A. Vieira, Romeu Vicente, Humberto Varum and J. A. R. Mendes da Silva</p>
<b>12:30-14:30</b>	Lunch
<b>14:30-16:00</b>	<p>Session 7 (auditorium)  Scope 6 - Assessment, conservation, repair and strengthening  Chairmen: Maciej Orzechowski and Zofia Zieba</p>
<b>S6.05</b>	<p><i>Fair-faced concrete and anti-graffiti protection</i>  Elsa Neto, Aires Camões, Ana Souto, Arlindo Begonha and Paulo Cachim</p>
<b>S6.09</b>	<p><i>Experimental study of repair and retrofit procedures to damaged RC columns</i>  Hugo Rodrigues, André Furtado, António Arêde, Nelson Vila-Pouca and Humberto Varum</p>

- S1.03** *Behaviour of cold-formed steel screwed connections at ambient and elevated temperatures*  
Rui Dias, Armandino Parente, Luís Mesquita, Paulo Piloto
- S6.12** *Refurbishment and maintenance strategies for social housing*  
Fernanda Rodrigues, Ana Simões, Maria João Matos, Aníbal Costa, Romeu Vicente, Manuela Álvares and José Ferreira
- S2.03** *Thermal model for charring rate calculation in wooden cellular slabs under fire*  
Djaafer Haddad, Elza M. M. Fonseca and Belkacem Lamri
- S2.05** *Stability of partially encased columns under fire*  
Abdelkadir Fellouh, Nourredine Benlakehal, Paulo Piloto, Ana Ramos and Luís Mesquita

**16:00-16:30**

Coffee Break

**16:30-17:00**

Closing Ceremony (auditorium)

António Fontainhas Fernandes  
Rector of the University of Trás-os-Montes e Alto Douro, Portugal

Bento Aires  
Coordinator of the Civil Engineering College of the North Region of Ordem dos Engenheiros, Portugal

António Valente  
Head of the Department of Engineering, School of Sciences and Technology, University of Trás-os-Montes e Alto Douro, Portugal

Maciej Orzechowski, on the behalf of the co-chairman of the Scientific Committee  
Wroclaw University of Environmental and Life Sciences, Poland

Silvija Strausa, co-chairman of the Scientific  
Committee,  
Latvia University of Agriculture, Jelgava, Latvia

Jorge Tiago Pinto, chairman of the Scientific  
Committee,  
University of Trás-os-Montes e Alto Douro, Portugal