COST Action TU1207

Next Generation Design Guidelines for Composites in Construction

GENERAL MEETING

State-of-the-art

ESR Think Tank

Management Committee Meeting

19-21 May 2015

Practical Information Guide
Technical Programme

19 - 21 May 2015
Lecce, Italy

ESF provides the COST Office through a European Commission contract

COST is supported by the EU Framework Programme

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Local Organising Committee

Professor Maria Antonietta AIELLO (Chair)
Ing. Francesco Micelli
Ing. Marianovella Leone
Dipartimento di Ingegneria dell'Innovazione

UNIVERSITÀ DEL SALENTO

Contents

About COST

Founded in 1971, COST – European Cooperation in Science and Technology – is the first and widest European framework for the transnational coordination of nationally funded research activities. It is based on an inter-governmental agreement between 35 European countries.

COST enables break-through scientific developments leading to new concepts and products and thereby contributes to strengthen Europe's research and innovation capacities.

It is a unique means for European researchers to jointly develop their own ideas and new initiatives across all scientific disciplines through trans-European networking of nationally funded research activities.

COST key features are:

- building capacity by connecting high-quality scientific communities throughout Europe and worldwide;
- providing networking opportunities for early career investigators
- increasing the impact of research on policy makers, regulatory bodies and national decision makers as well as the private sector.

Through its inclusiveness, COST supports integration of research communities, leverages national research investments and addresses issues of global relevance.

As a precursor of advanced multidisciplinary research, COST plays a very important role in building a European Research Area (ERA). It anticipates and complements the activities of the EU Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries. It also increases the mobility of researchers across Europe and fosters the establishment of scientific excellence in the nine key domains:

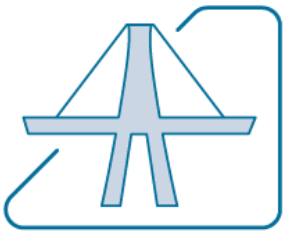
- Biomedicine and Molecular Biosciences
- Food and Agriculture
- Forests, their Products and Services
- Materials, Physics and Nanosciences
- Chemistry and Molecular Sciences and Technologies
- Earth System Science and Environmental Management
- Information and Communication Technologies
- Transport and Urban Development
- Individuals, Societies, Cultures and Health

In addition, Trans-Domain Proposals allow for broad, multidisciplinary proposals to strike across the nine scientific domains.

COST is funded through the EU RTD Framework Programmes.

About Transport and Urban Development (TUD)

TUD fosters research coordination in the fields of transport and the built environment, which play a strategic role in the modern society and economy.



The Domain is by definition cross-sectoral and multidisciplinary, encompassing a wide range of scientific expertise within the transport and land use planning, design, and management activities with a special emphasis on the strong interrelationships among the relevant policy fields as well on all aspects related to sustainable development.

The domain activities should be innovative and complementary to other European programmes in the relevant fields. The aim is to cover both basic and applied research activities including technical and technological developments and their changeovers that are relevant to policy and decision making processes.

A significant concern is devoted to activities exploring new research needs and developments.

About COST Action TU 1207

Construction is rapidly becoming the leading outlet for FRP composites. Although the use of composite materials in construction started in the 1980s, civil engineers only recently started gaining confidence in this technology for use in primary structural applications. Despite the considerable technological developments in this field, there are still key scientific and logistical issues that need to be addressed for the widespread acceptance in construction. For example, existing design recommendations are largely based on work carried out more than fifteen years ago on first generation reinforcing products and their conservativeness is hindering the development of innovative and more efficient products and design solutions.
This Action aims to:

- coordinate European research in the field
- develop and maintain a critical mass of researchers
- offer a link between academia and industry
- develop a new generation of design guidelines based on European Standards

This will facilitate the adoption of European products not only in Europe but also internationally and help Europe stay one step ahead of International competitors.

General information

Start of Action: 12/04/2013
End of Action: 11/04/2017

Chair of the Action: Dr Maurizio GUADAGNINI (UK)
Vice Chair of the Action: Prof Stijn MATTHYS (BE)

Scientific Officer: Dr Mickael PERO
Administrative Officer: Ms Carmencita MALIMBAN

Domain website: http://www.cost.eu/tud
Action website: http://www.tu1207.eu

Action TU1207 Working Groups

WG1 Material Development and Characterisation

Chair: Renata KOTYNIA (PL)
Co-Chair: Adorjan BOROSNYOI (HU)

- Assessing the different tests so as to select candidates for standardisation
- Bond behaviour of FRPs to concrete, steel, timber and masonry
- Behaviour of FRPs at elevated temperatures
- Accelerated tests and development of models to assess durability of FRPs in typical environments, including embedment in cement mortars and concrete

WG2 New Reinforced Concrete (RC) Structures

Chair: Lluis TORRES (ES)
Co-Chair: Kypros PILAKOUTAS (UK)

- Serviceability requirements
- New products and prefabricated solutions
- Long-term behaviour
- Behaviour of FRP RC elements exposed to fire or elevated temperatures

WG3 Strengthening Applications

Chair: Thanasis TRIANTAFILLOU (EL)
Co-Chair: Francesca CERONI (IT)

- Behaviour of confined concrete using different types of fibres and bonding systems
- Behaviour of strengthened reinforced concrete, masonry, steel and timber elements, in flexure, shear and punching shear
- Models and techniques for the prestressing of strengthening systems to enhance the utilisation of composites at service conditions
- Novel seismic strengthening and rehabilitation solutions and development of design models to avoid shear, anchorage, splice and buckling failures

WG4 Whole-life-costing and life cycle assessments

Chair: Matthias PAHN (DE)
Co-Chair: Jose SENA CRUZ (PT)

- Whole-life cost assessment of new FRP reinforced concrete structures
- Whole-life cost assessment of rehabilitated structures
- Recycling and reuse of composite materials
- Innovative structural solutions using existing and future materials

WG5 Knowledge Transfer

Chair: Joaquim BARROS (PT)
Co-Chair: Christoph CZADERSKI (CH)

WG5 will coordinate and promote inter-sectorial collaboration and outreach activities, including the maintenance and management of the Action website, organisation of industry seminars, training schools, Short-Term Scientific Mission (STSMs), maintenance of online databases, preparation and dissemination of reports and publications.

Programme at a glance

Venue: **Codacci-Pisanelli building**
Università degli Studi del Salento
Viale dell' Universita', 2
73100 Lecce, Italy

Tuesday 19 May

08:30 – 09:00	*Arrival and Registration*
09:00 – 09:25	**Opening** (welcome & introductions)
09:25 – 09:45	Introduction of Activities
09:45 – 11:00	**Material Development and Characterisation**
11:00 – 11:30	Coffee Break
11:30 – 12:30	**Composites in Construction in the COST Countries: An Overview**
12:30 – 14:00	Lunch
14:00 – 15:30	**Composite Reinforcement in New Concrete Structures: Analysis, Testing and Design**
15:30 – 16:00	Coffee Break
16:00 – 17:00	**Strengthening with Composites: Reinforced Concrete Structures**
17:00	**Closure of Day 1**

Wednesday 20 May

08:30 – 09:00	*Arrival and Registration*
09:00 – 09:15	**Opening**
09:15 – 11:00	**Strengthening with Composites: Reinforced Concrete Structures**
11:00 – 11:30	Coffee Break
11:30 – 12:30	**Strengthening with Composites: Steel, Timber and Masonry Structures**
12:30 – 14:00	Lunch
14:00 – 15:30	**COST Action TU1207 MC Meeting**
15:30 – 16:00	Coffee Break
16:00 – 17:00	**COST Action TU1207 CORE Group Meeting**
17:00	**Closure of Day 2**

20:30	COST TU1207 *Official Dinner*

Thursday 21 May

08:30 – 09:00	*Arrival and Registration*			
09:00 – 09:10	**Opening**			
09:10 – 10:30	**New Composite-based Materials, Systems and Strengthening Techniques**			
10:30 – 11:00	Coffee Break			
11:00 – 12:30	WG1 Material Development and Characterisation	WG2 New Reinforced Concrete (RC) Structures	WG3 Strengthening Applications	WG4 Whole-life-costing and life cycle assessments
12:30 – 13:00	**Closure of General Meeting**			
13:00 – 14:30	Lunch		Early Stage Researchers Lunch/Think Tank	
14:30 – 15:30	**ESR Think Tank** (continued)			

Workshop on **Strengthening with composites: Textile Reinforced Mortar Systems**

RILEM TC250/COST Action TU1207

15:30 – 18:30	**Strengthening with composites: Textile Reinforced Mortar Systems** Session chairs: Gianmarco de Felice, Maurizio Guadagnini

The final programme might be subject to change

Detailed programme of activities

Tuesday 19 May

08:30 – 09:00	*Arrival and Registration*
09:00 – 09:25	**Opening**
09:25 – 09:45	Introduction of Activities *Session chairs: Maurizio Guadagnini, Maria Antonietta Aiello*
09:45 – 11:00	**Material Development and Characterisation** *Session chairs: Renata Kotynia, Vineta Srebrenkoska*
	Results of Research on Highly Deformable Adhesives: An Overview of Cooperation of Italy, Poland, Portugal and Slovenia *Arkadiusz Kwiecień* Mechanical Characterization of the Glass Fiber Reinforced Pipes for Construction *Vineta Srebrenkoska, Renata Kotynia, Krzysztof Bojanowski, Silvana Zhezhova* Creep Behavior of Cold-curing Epoxy Adhesives: Analysis and Predictive Approach *Karim Benzarti, Noureddine Houhou, Marc Quiertant, Sylvain Chataigner*
11:00 – 11:30	Coffee Break
11:30 – 12:30	**Composites in Construction in the COST Countries: An Overview** *Session chairs: Cristina Miàs, José Sena-Cruz*
	Composites in Construction in the UK: Research Activities *Maurizio Guadagnini* Composites in Construction in Lithuania: Experimentation, Theory, and Practice *Gintaris Kaklauskas, Viktor Gribniak, Arvydas Rimkus, Adas Meskenas, Vytautas Tamulenas* Polish-Swiss Collaboration in Strengthening of Concrete Bridge Girders with Pretensioned CFRP Laminates – Tulcoempa Project *Renata Kotynia, Julien Michels, Michal Staskiewicz, Christoph Czaderski, Masoud Motavalli* Recent Development in the FRP for Transport Infrastructure in Czech Republic *Ryjacek Pavel, Simon Pavel*
12:30 – 14:00	Lunch
14:00 – 15:30	**Composite Reinforcement in New Concrete Structures: Analysis, Testing and Design** *Session chairs: Cristina Barris, Lluis Torres*
	Thermo-Mechanical Behaviour of GFRP Reinforced Thin Concrete Panels *Andreas Schmitt, Valter Carvelli, Matthias Pahn* Flexural Capacity of Concrete Members Reinforced with FRP Bars *Lluis Torres, Cristina Barris, Cristina Miàs* Shear Behaviour of FRP RC Beams *Maurizio Guadagnini, Fang Yang, Szymon Cholostiakow* Prestressing with FRP Reinforcement *Ted Donchev, Mohammad Mirshekari and Diana Petkova*
15:30 – 16:00	Coffee Break

16:00 – 17:00	**Strengthening with Composites: Reinforced Concrete Structures** *Session chairs: Eva Oller, Theodoros Rousakis*
	Accuracy of Analytical Formulations for the Evaluation of Flexural and Shear Resistance of FRP Strengthened RC Beams *Tommaso D'Antino, Thanasis Triantafillou* Efficiency of Flexural Strengthening RC Members with Pretensioned EB and NSM FRP Composites *Renata Kotynia, Krzysztof Lasek, Michal Staskiewicz, Marta Przygocka* Assessment of the Effectiveness of NSM Prestressed CFRP Laminates for the Flexural Strengthening of RC Beams: Experimental Evidence and Analytical Formulation *Joaquim Barros and Mohammadali Rezazadeh*
17:00	**Closure of Day 1**

Wednesday 20 May

08:30 – 09:00	*Arrival and Registration*
09:00 – 09:15	**Opening**
09:15 – 11:00	**Strengthening with Composites: Reinforced Concrete Structures** *Session chairs: Janet Lees, Dionysios Bournas*
	Bond Durability and Quality Control of NSM-Concrete Systems *José Sena-Cruz, Pedro Fernandes, Patrícia Silva, Andrea Benedetti, José Granja and Miguel Azenha* The Mechanical Response of Basalt Fiber Reinforced Polymer External Reinforcement of Cylindrical Concrete Elements Loaded in Compression *Todor Zhelyazov, Eythor Thorhallsson and Jónas Snæbjörnsson* Seismic Retrofit of Precast RC Wall Panels with Openings Using FRP Strengthening Strategies *Valeriu Stoian, Carla Todut, Nicolae Taranu* Assessment of the Existing Formulations to Evaluate the Shear Strength of FRP-Shear Strengthened Beams *Eva Oller, Renata Kotynia, Monika Kaszubska* FRP Contribution to Shear Strength in Support Regions of RC Beams Strengthened with Composite Materials *Renata Kotynia, Eva Oller, Monika Kaszubska*
11:00 – 11:30	Coffee Break
11:30 – 12:30	**Strengthening with Composites: Steel, Timber and Masonry Structures** *Session chairs: Maria Antonietta Aiello, Carlo Pellegrino*
	Fatigue Strengthening of Riveted Girders in a 120-Year-old Railway Metallic Bridge Using Pre-stressed CFRP Laminates *Elyas Ghafoori* Advances in Strengthening of Natural Masonry with Composite Materials *Maria Antonietta Aiello, Marianovella Leone, Francesco Micelli*

	Bond Behavior of FRCM Composites Applied on Concrete and Masonry Elements *Jaime Gonzalez, Tommaso D'Antino, Carlo Pellegrino*
12:30 – 14:00	Lunch
14:00 – 15:30	**COST Action TU1207 MC Meeting**
15:30 – 16:00	Coffee Break
16:00 – 17:00	**COST Action TU1207 CORE Group Meeting**
17:00	**Closure of Day 2**

20:30	COST TU1207 *Official Dinner*

Thursday 21 May

08:30 – 09:00	*Arrival and Registration*			
09:00 – 09:10	**Opening**			
09:10 – 10:30	**New Composite-based Materials, Systems and Strengthening Techniques** *Session chairs: Corina Papanicolau, Stefano De Santis*			
	Experimental Evaluation of RC Beams Prestressed by C- strips *Miroslav Cerny* Analytical Modeling of Externally Strengthened RC Columns with Degrading Stress-Strain Behaviour *Theodoros Rousakis* Experimental Characterisation of Textile Reinforced Mortar *Gianmarco de Felice, Stefano De Santis* Textile-Reinforced Mortar (TRM) versus Fiber-Reinforced Polymers (FRP) in Shear Strengthening of Concrete Beams *Zoi Tetta, Lampros Koutas and Dionysios Bournas*			
10:30 – 11:00	Coffee Break			
11:00 – 12:30	WG1 Material Development and Characterisation	WG2 New Reinforced Concrete (RC) Structures	WG3 Strengthening Applications	WG4 Whole-life-costing and life cycle assessments
12:30 – 13:00	**Plenary Session** **Closure of General Meeting**			
13:00 – 14:30	Lunch		Early Stage Researchers Lunch/Think Tank *Chair: Dionysios Bournas*	
14:30 – 15:30	**ESR Think Tank** (continued) *Chair: Dionysios Bournas*			

Workshop on **Strengthening with composites: Textile Reinforced Mortar Systems**

RILEM TC250/COST Action TU1207

15:30 – 18:30	**Strengthening with composites: Textile Reinforced Mortar Systems** Session chairs: Gianmarco de Felice, Maurizio Guadagnini
	Qualification for Externally Bonded Fabric Reinforced Cementitious Matrix (FRCM) Systems *Luigi Ascione* Tensile Properties of Fabric Reinforced Cementitious Matrix (FRCM) Systems for Masonry Strengthening *Francesca Giulia Carozzi, Carlo Poggi* Debonding of FRCM from a Quasi-Brittle Substrate: State of the Art and New Challenges *Christian Carloni* TRM Systems for Strengthening Masonry Walls Under In-plane Loads *Corina Papanicolau* TRM Systems for Strengthening Masonry Walls Under Out-of-plane Loads: State of the Art and Recent Shake-table Experimental Outcomes *Stefano De Santis*

The final programme might be subject to change

Abstracts

Material Development and Characterisation

Results of Research on Highly Deformable Adhesives: An Overview of Cooperation of Italy, Poland, Portugal and Slovenia

Arkadiusz Kwiecień

An innovative approach, improving the bond of composite materials to masonry and concrete, is the use of deformable polymers as the adhesive. Such materials are non-linear elastic with stiffness two or three orders (depending on the type) of magnitude smaller than the stiffness of mortar or epoxy resin. They are also highly deformable and capable of withstanding deformation of 60% or more without damaging. This material, contrary to engineering intuition, improves e.g. the performance of seismically strengthened walls and prevents the loss of bond even at collapse. Research on this deformable adhesive was started in Poland and was continued by universities in Italy (8), Poland (2), Portugal (1) and Slovenia (1) in the frame of an international cooperation based on COST Action TU 1207. Obtained results were published in 14 papers in years 2013-15 and 3 are submitted for publication this year. In frame of the COST Action TU 1207 one STSM was realized by the ESR Matija Gams at Cracow University of Technology at the beginning of the year 2015. Its title was “Deformable polymers as adhesive for FRPs” and the aim of the STSM was to develop new numerical models for modeling deformable polymers.

Mechanical characterization of the glass fiber reinforced pipes for construction

Vineta Srebrenkoska, Renata Kotynia, Krzysztof Bojanowski, Silvana Zhezhova

The focus of this lecture will be investigation of some mechanical characteristics: hoop tensile strength and transverse compressive properties of different models of filament wound pipes. The preparation of the different models of composites was done by applying the full factorial experimental design by using of three parameters: velocity of the filament winding, fibre tension and winding angle and two levels of variation. Based on the investigation from the mechanical point of view there are significant differences in the filament wound pipes with different fiber orientation. Regarding the tensile properties, the bigger winding angle lead to higher hoop tensile properties of filament-wound tubular samples. But, for the transverse compression properties of composite pipes the lower winding angle lead to higher transverse compression properties of the pipes.

Creep behavior of cold-curing epoxy Adhesives: analysis and predictive approach

Karim Benzarti, Noureddine Houhou, Marc Quiertant, Sylvain Chataigner

This study investigates the creep behavior of two commercially available cold-curing epoxy adhesives, intended for the bonding of external composite reinforcements on concrete structures. In a preliminary stage, the characteristics of the mineral fillers (nature, content and size) contained in the two systems were determined, and the viscoelastic properties of the unfilled epoxy matrices extracted from these systems were analyzed. Short-term tensile creep experiments were then carried-out on cured samples of the two adhesives and their unfilled matrices, in order to evaluate the influence of the fillers and the polymer network characteristics on the instantaneous and delayed mechanical responses. Finally, two predictive approaches based on either the Time-Temperature Superposition Principle (TTSP) or the Time-Stress Superposition Principle (TSSP) were applied to evaluate the long-term creep behavior, and their suitability in the case of cold-curing adhesives was discussed.

Composite Reinforcement in New Concrete Structures: Analysis, Testing and Design

Thermo-Mechanical Behaviour of GFRP Reinforced Thin Concrete Panels
Andreas Schmitt, Valter Carvelli, Matthias Pahn

The experimental investigation is focused on the thermo-mechanical behaviour of thin concrete panels reinforced with GFRP rebars. The considered thin panels of 4 cm thickness were exposed to increasing temperature and bending loading. These concrete elements are typical for low bearing function concrete layers in façade claddings. The influence of two aspects was studied: the concrete cover and the external surface of rebars. The heating was such that the temperature of the internal GFRP bars was about the transition temperature of the resins. The deformability and the load carrying capacity of the panels with post-heating bending tests were verified.

Flexural capacity of concrete members reinforced with FRP bars
Lluis Torres, Cristina Barris, Cristina Miàs

FRP reinforced concrete members may fail in flexure either due to concrete crushing (compressive failure type) or rupture of the FRP bars (tensile failure type). The design concepts involved in the flexural design of FRP RC members are similar to those used for conventional steel RC, although the changes in philosophy and the linear behaviour of the FRP bars lead to the sectional properties having a different influence on the design. Furthermore, different design equations and procedures have been developed for the flexural design of FRP RC with special emphasis placed on the requirement of iterative procedures when dealing with failure due to FRP rupture. In this presentation a summary of the procedures for flexural design using American or European approaches will be shown, followed by the development of non-dimensional and simplified equations based on Eurocode 2 methodology leading to a closed-form equation for the case of failure due to FRP rupture. The equations can be used to obtain design tools which can help in the design and allow to reflect the influence of the influencing parameters.

Shear behaviour of FRP RC beams
Maurizio Guadagnini, Fang Yang, Szymon Cholostiakow

Shear behaviour of reinforced concrete members is a complex phenomenon that relies on the development of internal carrying mechanisms, the magnitude and combination of which is still a subject of debate. The development of all of these basic mechanisms depends largely on the mechanical properties of the reinforcing material and the nature of the interaction between concrete and reinforcement.
This work summarises the experience from a series of past and ongoing experimental programmes carried out at the University of Sheffield and discussed how the use of FRP reinforcement affects the overall shear behaviour of reinforced concrete beams, in terms of both strength and deformation, and how the different nature of the internal reinforcement can be accounted for in the development of design recommendations.

Prestressing with FRP reinforcement
Ted Donchev, Mohammad Mirshekari and Diana Petkova

The usage of BFRP and GFRP reinforcement in new RC structures is governed usually by SLS design. One of possible approaches to decrease deformability and to increase the effectiveness of FRP reinforced structural elements is via introducing of prestress. An overview of latest achievements including some unpublished recent experimental results clearly indicate opportunity to use of different levels of prestressing for achieving more effective behaviour of BFRP reinforced structural elements."

Strengthening with Composites: Reinforced Concrete Structures

Accuracy of analytical formulations for the evaluation of flexural and shear resistance of FRP strengthened RC beams

Tommaso D'Antino, Thanasis Triantafillou

Fiber reinforced polymer (FRP) composites have been largely employed in the last few decades for strengthening and retrofitting existing reinforced concrete (RC) structures. Several studies are available in the literature and different analytical models were proposed for the evaluation of the FRP contribution in strengthened RC elements. This paper analyzes the accuracy of widely used analytical models, some of which are included in design codes, for the evaluation of flexural and shear contributions provided by the EB FRP composites. In particular, the analytical models for the evaluation of the FRP strain at intermediate crack-induced debonding failure are analyzed. The accuracy of each formulation is assessed comparing the analytical provisions with the experimental results collected within a bending and a shear databases. The results obtained showed that most of the analytical flexural models attained a good level of accuracy and only few models provide inadequate results.

Efficiency of flexural strengthening RC members with pretensioned EB and NSM FRP composites

Renata Kotynia, Krzysztof Lasek, Michal Staskiewicz, Marta Przygocka

Presentation shows an overview of variable kinds of flexural strengthening of RC members with pretensioned FRP laminates. The summary of experimental tests results based on two main groups of strengthening namely externally bonded (EB) and near surface mounted (NSM) are presented are compared and discussed. Benefits and disadvantages of both techniques are presented. Strengthening efficiency is justified in discussion of main investigated parapets: concrete strength, existing internal steel reinforcement ratio, FRP ratio, pre-loading level and pre-tensioning FRP strain. Failure modes, strengthening ratio (in comparison with the reference RC members) are described regarding to ULS and SLS. Benefits of NSM in comparison EBR technique show much higher utilization of the FRP tensile strength. Analytical model considering nonlinear analysis of concrete and preloading level is presented. Comparison of calculated and test results confirms compatibility of the model with the test results in a full range of load.

Assessment of the effectiveness of NSM prestressed CFRP laminates for the flexural strengthening of RC beams: experimental evidence and analytical formulation

Joaquim Barros and Mohammadali Rezazadeh

The main purpose of the current study is to experimentally demonstrate the efficiency of a flexural strengthening methodology using the NSM CFRP technique for the enhancement of the load carrying capacity at concrete cracking and steel yielding initiations, serviceability limit state, and ultimate condition, when NSM CFRP laminates are applied with a certain. A simplified analytical approach, with a design framework, is proposed to predict the flexural behavior of RC beams flexurally strengthened with prestressed CFRP reinforcement applied according to either EBR or NSM techniques.

Bond durability and quality control of NSM-concrete systems

José Sena-Cruz, Pedro Fernandes, Patrícia Silva, Andrea Benedetti, José Granja and Miguel Azenha

The presentation will summarize the main contributions by the authors for the knowledge on the durability and quality control of concrete structures strengthened with the Near-Surface Mounted (NSM) technique. In terms of the durability, the effect of the environmental conditions, such as freeze-thaw cycles, pure water, water with chlorides, wet-dry cycles and temperature cycling on the bond performance will be given. Regarding to the second issue, a NDT method is presented for quality control and assistance to decision-making for the reinforcement technique.

The mechanical response of Basalt Fiber Reinforced Polymer external reinforcement of cylindrical concrete elements loaded in compression

Todor Zhelyazov, Eythor Thorhallsson and Jónas Snæbjörnsson

Basalt fiber reinforced polymer (BFRP) is a relatively new material for construction. It possesses good corrosion-resistance, light weight and an attractive price. In this paper the mechanical response of cylindrical concrete specimens externally wrapped by uni-directional BFRP's is studied, both experimentally and numerically. Standard concrete cylinders were tested with and without BFRP reinforcement. The experimental specimens tested are modelled using the finite element technique. The geometry and material properties are modelled with considerable accuracy. In the FE modelling the BFRP wrapped concrete specimens are seen as a multiple-component system and constitutive laws are defined for all the components of the system. The BFRP wrapping is modelled as a transversely isotropic material which exhibits linear elastic response until failure. The concrete is modelled by assuming elastic behaviour coupled with anisotropic damage. A perfect bond is assumed between the concrete and the BFRP wrapping. To validate the results of this on-going study, the results obtained by the finite element analysis are compared to experimentally obtained macro characteristic, such as the stress-strain relationship. Two distinct phases in the response of the BFRP wrapped concrete cylindrical specimens can be detected. In the first phase the load is resisted mainly by concrete. After degradation of concrete due to damage accumulation, the macro response of the confined specimens is governed by the external BFRP reinforcement. The post-failure concrete behaviour is modelled by updating its mechanical properties (Young modulus and Poisson's ratio) in function of the amount of the accumulated damage. Since the rigidity of the confined specimens after concrete failure is provided mainly by the BFRP wrapping it can be assumed that in the second phase the macro-response reflects principally the BFRP mechanical properties.

Seismic retrofit of precast RC wall panels with openings using FRP strengthening strategies

Valeriu Stoian, Carla Todut, Nicolae Taranu

Research was developed in the form of theoretical, numerical and experimental investigations, comprising mostly as-built walls with or without openings. The main investigation interests were focused on the seismic performance, weakening effects, numerical assessment and structural rehabilitation using FRPs.

Assessment of the existing formulations to evaluate the shear strength of FRP-shear strengthened beams

Eva Oller, Renata Kotynia, Monika Kaszubska

During the STSM performed at the Lodz University of Technology by the first author, a common database of shear tests on EB FRP shear-strengthened beams has been established. Then, a comparison of the existing formulations to evaluate the FRP contribution on the shear strength of EB-FRP RC beams has been performed. Finally, a critical analysis of this comparison has been done and the main parameters that have a strong influence on the shear response have been identified.

FRP contribution to shear strength in support regions of RC beams strengthened with composite materials

Renata Kotynia, Eva Oller, Monika Kaszubska

Presentation refers a problem of shear capacity of the support regions in reinforced concrete (RC) beams, which due to deficiency of the capacity need strengthening. The work is the result of the analysis of the other and author's experimental studies, which enabled to evaluate the strengthening effectiveness, depending on the chosen investigated parameters: degree of transversal steel and composite reinforcement, strength characteristics of steel and composites, concrete strength, shear span to depth ratio and composite applications. The fundamental objective of the study was to create a comprehensive database, which includes the results of the experimental studies of the RC members shear strengthened with different fiber reinforced polymer (FRP) composites. The authors discuss in detail the experimental research making a synthesis of knowledge based on the selected and the most cognitive test results with the analysis of the strengthening efficiency in terms of the investigated parameter.

Strengthening with Composites: Steel, Timber and Masonry Structures

Fatigue strengthening of riveted girders in a 120-year-old railway metallic bridge using pre-stressed CFRP laminates

Elyas Ghafoori

Metallic Structures subjected to repeated loads will ultimately fail through a process of material fatigue, with the material fatigue-life being directly related to the repeated load value. Higher loads typically correspond with lower fatigue-life. Many old riveted bridges still in operation are subjected to ever increasing loads and require retrofit to extend the remaining fatigue-life.
Many commonly used retrofit methods include welding and bolting additional steel elements and are prohibited or difficult to install. Recent studies have shown that carbon-fiber reinforced polymer (CFRP), as a light composite material, has a potential to substantially enhance the fatigue life of metallic structures. However, nearly all of these studies have used CFRP-to-steel bonded joints. Nevertheless, there are concerns about environmental conditions as well as dynamic loadings that can potentially degrade the performance of bonded joints.
In this presentation, an innovative pre-stressed un-bonded reinforcement (PUR) system is presented. The developed PUR system offers a fast on-site installation procedure (i.e., no glue and no surface preparation are required), which substantially reduces the time and the work required for strengthening.
Furthermore, this research work examines the applicability of the constant life diagram (CLD) methodology for determination of strengthening parameters to prevent fatigue cracks in aging metallic members. The CLD methodology is an approach that uses the combined effect of alternating stress, mean stress and material properties to predict the material lifetime under high cycle fatigue.
Lastly, details about fatigue strengthening of riveted girders in a 120-year-old railway metallic bridge using the PUR system such that the requirements of the CLD approach are fulfilled are presented.

Advances in Strengthening of Natural Masonry with Composite Materials

Maria Antonietta Aiello, Marianovella Leone, Francesco Micelli

The need to guarantee higher safety level of masonry structures under both short and long term conditions, have led to the use of composite materials and technologies in conjunction or in place to traditional ones. In this context, fiber-reinforced composite materials have gained an increasing success and many researchers have been carried out studies on strengthening and/or restoration of existing structures. However the technical literature needs to be extended regarding to masonry structures.
The scientific contribution, performed at the University of Salento, is mainly referred to the bond between natural stone and composite reinforcement, to the confinement of masonry columns and to the in plane shear behavior of reinforced masonry panels. Different experimental campaigns have been carried out and the results are reported and discussed. In addition, theoretical formulation useful in design code have been calibrated.

Bond behavior of FRCM composites applied on concrete and masonry elements

Jaime Gonzalez, Tommaso D'Antino, Carlo Pellegrino

The growing need for strengthening and retrofitting existing structures has led to the development of innovative strengthening materials such as Fibre Reinforced Cementitious Matrix (FRCM) composites. FRCM, comprised of high-strength fibres and an inorganic matrix, has shown a better resistance to high temperature and compatibility with the substrate than traditional fibre reinforced polymer (FRP) composites. This contribution presents the results of single-lap direct-shear tests on FRCM-concrete and –masonry joints, carried out to investigate their bond behavior. Observations regarding the load response and failure mode with different types of fibres and geometrical and mechanical characteristics are provided.

Experimental Evaluation of RC Beams Prestressed by C- strips
Miroslav Cerny

The results of static tests of concrete beams in bending, strengthened by prestressed carbon strips are presented. C-strips have been located on bottom of the beam and prestressed by 30 kN and 50 kN forces. The tests have been focused on analysis of failure mechanisms of RC beams and comparison of loading capacity prestressed and nonprestressed RC beams strengthened by adhesive bonded anchored C- strips.

New Composite-based Materials, Systems and Strengthening Techniques

Analytical modeling of externally strengthened RC columns with degrading stress-strain behaviour
Theodoros Rousakis

Most existing FRP confinement stress-strain models may reproduce with great accuracy ever-increasing bilinear stress-strain behavior of concrete (common for circular columns). Yet, they generate significant predictive errors in cases of columns with experimentally observed softening stress-strain behavior. This behavior is more or less typical for real-size non-circular FRP confined RC columns or for columns confined with new composite materials or new techniques (hybrid or not). Suitable analytical modeling is explored to cover abovementioned cases.

Experimental Characterisation of Textile Reinforced Mortar
Gianmarco de Felice, Stefano De Santis

The strengthening systems based on textiles externally bonded with mortar are currently used in retrofitting of concrete and masonry structures. However, neither rules for the design of strengthening, nor regulation for the product qualification are yet available. With respect to classical FRP, these systems ensure a better compatibility and sustainability, but a lower bond to the substrate, which could affect the structural performances. The talk will address current experimental research on these systems, including direct tensile and shear bond tests.

Textile-reinforced mortar (TRM) versus fiber-reinforced polymers (FRP) in shear strengthening of concrete beams
Zoi Tetta, Lampros Koutas and Dionysios Bournas

This paper presents an experimental study on shear strengthening of rectangular reinforced concrete (RC) beams with advanced composite materials. Key parameters of this study include: (a) the strengthening system, namely textile-reinforced mortar (TRM) jacketing and fiber-reinforced polymer (FRP) jacketing, (b) the strengthening configuration, namely side-bonding, U-wrapping and full-wrapping, and (c) the number of the strengthening layers. In total, 14 RC beams were constructed and tested under bending loading. One of the beams did not receive any strengthening and served as control beam, eight received TRM jacketing, whereas the rest five received FRP jacketing. It is concluded that the TRM is generally less effective than FRP in increasing the shear capacity of concrete, however the effectiveness depends on both the strengthening configuration and the number of layers. U-wrapping strengthening configuration is much more effective than side-bonding in case of TRM jackets and the effectiveness of TRM jackets increases considerably with increasing the number of layers.

About Lecce

Lecce is a historic city of 95,200 habitants in southern Italy, the capital of the province of Lecce, the second province in the region by population, as well as one of the most important cities of Apulia. It is the main city of the Salentine Peninsula, a sub-peninsula at the heel of the Italian Peninsula and is over 2,000 years old.

Because of the rich Baroque architectural monuments found in the city, Lecce is commonly nicknamed "The Florence of the South". The city also has a long traditional affinity with Greek culture going back to its foundation; the Messapi who founded the city are said to have been Cretans in Greek records. To this day, in the Grecìa Salentina, a group of towns not far from Lecce, the griko language is still spoken.

In terms of industry the "Lecce stone" is the city's main export, because it is very soft and malleable, thus suitable for sculptures. Lecce stone is a kind of limestone. Lecce is also an important agricultural centre, chiefly for its olive oil and wine production, as well as an industrial centre specialising in ceramic production.

Links of interest:

Apulia's Official Tourism Portal - Tourism Department and Tourism Promotion
The web portal is promoted and managed by the Department Mediterranean - Culture - Tourism of Regione Puglia.
www.viaggiareinpuglia.it
www.viaggiareinpuglia.it (Lecce)

Puglia Events

The www.pugliaevents.it website aims not only to keep attention focused on culture and shows in the region, but also to involve and coordinate those working in these areas. When it comes to visitors to the website, the aim is to become the reference point for the activities of operators living and working in Apulia, and for tourists planning their trip to the region. www.pugliaevents.it

Lecce Travel Guide – VirtualTourist www.virtualtourist.com

About Salento

The southernmost part of Italy's heel, the Salento begins (more or less - because differing opinions do exist!) where the hills of the Valle d'Itria end. From there, the land becomes a long flat tongue of land that laps two seas: the Adriatic to the east, the Ionian to the west.

The Salento is home to some of Italy's loveliest towns and cities: the sea-front

fortified gems of Gallipoli and Otranto, the creamy baroque sophistication of Lecce and the luxurious seaside Liberty pleasures of Leuca.

But the Salento is also full to brimming with small sleepy towns that are off the tourist trail but greatly worth visiting for their unspoilt historic centres and their unassuming genuineness. Examples include Specchia and the so-called Greek towns of Calimera, Carpignano Salentino, Castrignano dei Greci, Corigliano d'Otranto, Cutrofiano, Martano, Martignano, Melpignano, Soleto, Sternatia and Zollino.

These towns - around 20km south of Lecce - preserve the Salento's strong historic ties with Greece, dating back thousands of years. The local dialect, 'Grika', and many of the area's gastronomic, cultural and religious traditions have evident Hellenic roots which are celebrated with frequent festivals, including the hugely popular and energetic Notte della Taranta.

The Salento's hinterland plays a fundamental role in Italy's agricultural economy, producing enormous quantities of excellent olive oil and full-bodied, robust wines, such as Primitivo di Manduria and Salice Salentino, Negroarmaro

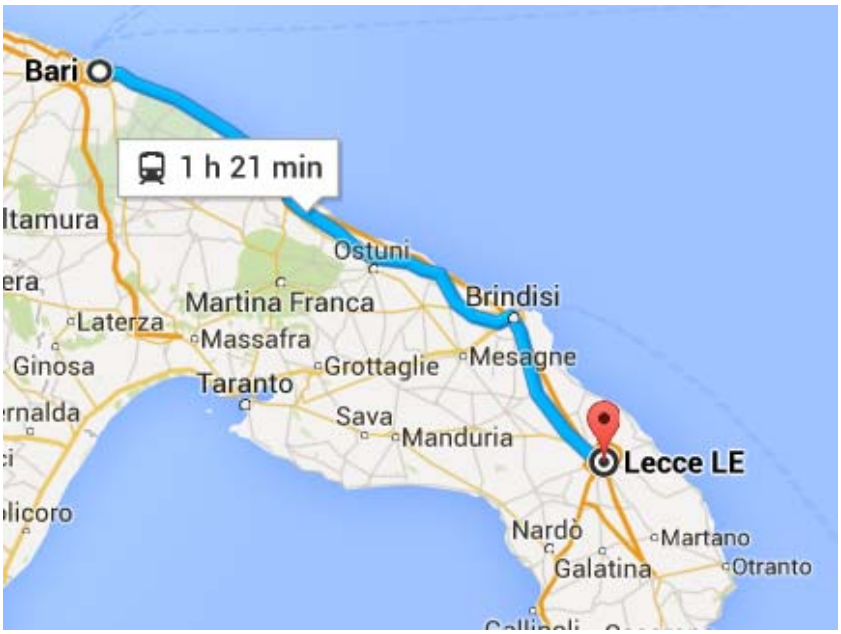
It is the long and varied coastline, however, that is the major attraction for the area's tourist industry. Home to some of Italy's loveliest beaches and most rocky coastline, the Salento is a haven for sea lovers. From the southernmost tip near Leuca, running up the west coast to Gallipoli and beyond, is a vast almost non-stop strip of paradisiacal golden sand and transparent azure waters. To the east, the Adriatic coastline is more varied, offering sandy beaches, Karstic grottoes, chalk cliffs and salt-water lagoons.

How to get to Lecce

FROM BARI PALESE AIRPORT TO LECCE TRAIN STATION:

A shuttle train service is provided from the airport to the Bari train station. The current timetable is available here. Moreover, the central station can be reached by private bus-shuttles (you can find it at the exit of the

airport); from there you can reach Lecce by train (about 1:30 hours, 33 trains per day). Train timetables are available here.



FROM BRINDISI AIRPORT TO LECCE

The Shuttle Bus service to Lecce stops at the city terminal (50 meters from the Grand Hotel Tiziano).

Shuttle Bus service timetables are available here. You can buy the ticket on the Shuttle Bus.

FROM									
LECCE - City terminal	05:35	07:15	09:50	11:00	13:05	15:00	17:05	18:20	20:15
TO									
BRINDISI - Aeroporto	06:15	07:55	10:30	11:40	13:45	15:40	17:45	19:00	20:05

FROM									
BRINDISI - Aeroporto	06:20	09:00	11:05	12:25	14:05	16:15	17:45	19:00	23:20
TO									
LECCE - City terminal	07:00	09:40	11:45	13:05	14:45	16:55	18:25	19:40	00:00

A bus from the airport to the Brindisi train station is available also every 30 minutes, and from there you can reach Lecce by train (about 30 min, 36 trains per day). Train timetables are available here.

Airshuttle provides a pool taxi service (about 20 euro). The ride has to be booked at least one day in advance.

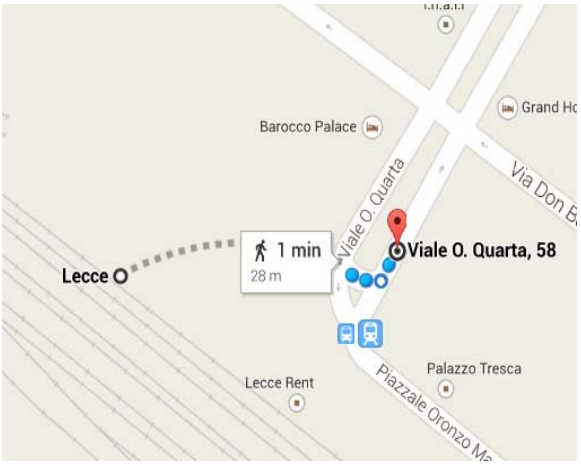
Taxi is also available (about 70 euro, we suggest to agree the price with the driver in advance). For more information, please click here.

Meeting venue

Meetings will be held at the Codacci-Pisanelli building. It is about 1,4 kilometers away from the Lecce train station.

To reach the Codacci-Pisanelli building from the Lecce train station, catch the buses s.g.m. number 27 or 27 Esatta and get off at Porta Napoli bus stop.

From Monday to Saturday, these buses leaves every 18/24 minutes (AM/PM) from the bus stop near the train station.

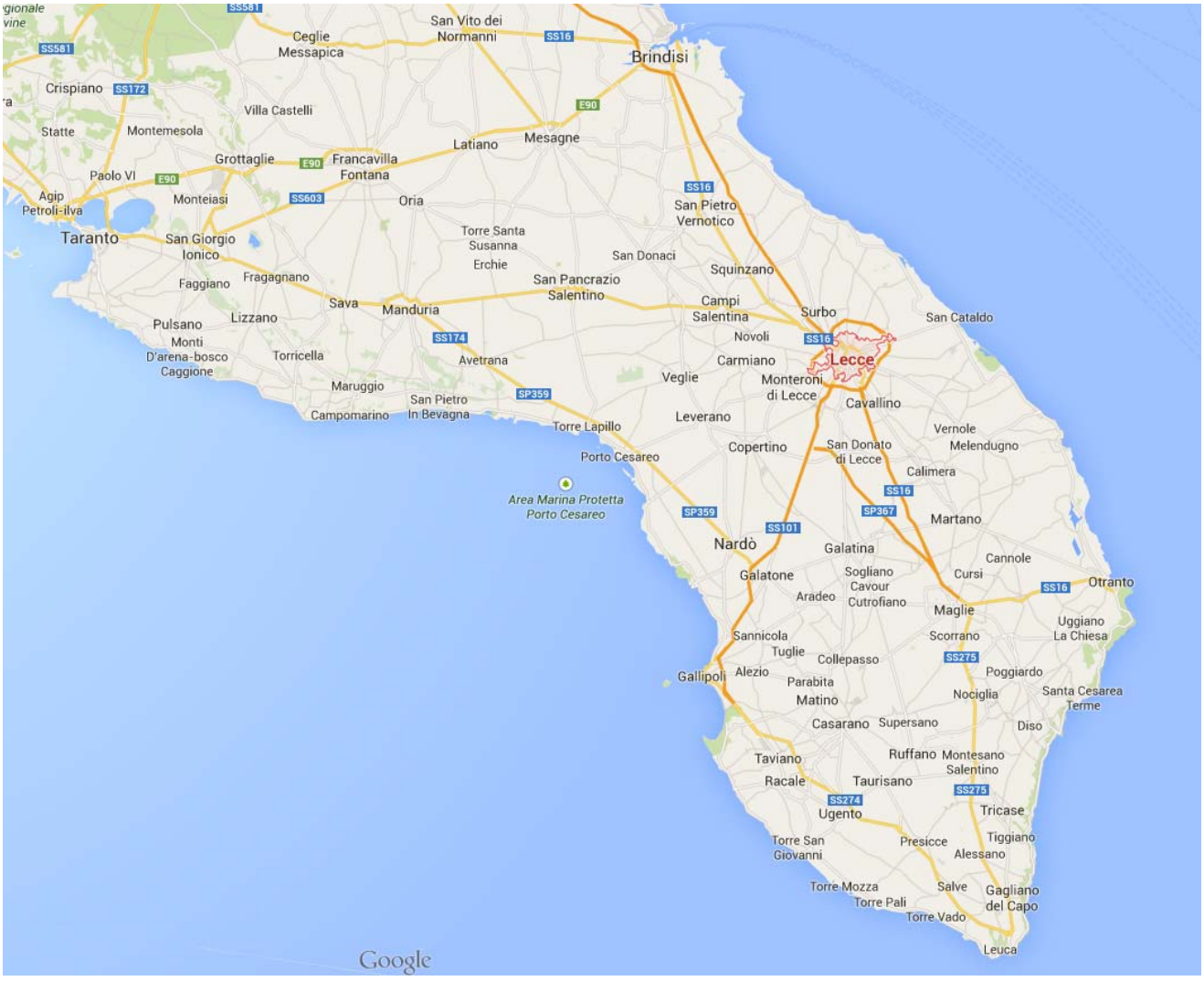


You can buy the bus ticket within the train station or inside the bus.

For more information about bus timetables and itinerary, please have a look at the following links:

- Bus 27/27 Esatta timetables
- Bus 27/27 Esatta itinerary

Maps


Brindisi
San Vito dei Normanni
Ceglie Messapica
Crispiano
Villa Castelli
Statte
Montemesola
Grottaglie
Francavilla Fontana
Latiano
Mesagne
Paolo VI
Agip Petroli-ilva
Monteiasi
Oria
Taranto
San Giorgio Ionico
Torre Santa Susanna
Erchie
San Donaci
Squinzano
San Pietro Vernotico
Faggiano
Fragagnano
San Pancrazio Salentino
Sava
Manduria
Campi Salentina
Surbo
San Cataldo
Pulsano
Lizzano
Monti D'arena-bosco Caggione
Torricella
Avetrana
Novoli
Carmiano
Lecce
Veglie
Monteroni di Lecce
Cavallino
Maruggio
San Pietro In Bevagna
Campomarino
Leverano
Torre Lapillo
Copertino
San Donato di Lecce
Vernole
Melendugno
Porto Cesareo
Area Marina Protetta Porto Cesareo
Calimera
Martano
Nardò
Galatina
Cannole
Galatone
Sogliano Cavour
Cursi
Otranto
Aradeo
Cutrofiano
Maglie
Uggiano La Chiesa
Sannicola
Scorrano
Tuglie
Collepasso
Gallipoli
Alezio
Parabita
Poggiardo
Matino
Nociglia
Santa Cesarea Terme
Casarano
Supersano
Diso
Taviano
Ruffano
Montesano Salentino
Racale
Taurisano
Ugento
Tricase
Torre San Giovanni
Presicce
Tiggiano
Alessano
Torre Mozza
Salve
Gagliano del Capo
Torre Pali
Torre Vado
Leuca
Google

Accommodation

Several hotels and the related contact information are listed below. Many of the suggested Hotels are at walking distance from the Conference location (Codacci-Pisanelli building). The hotels listed have made an agreement with the University of Salento. Conference participants are encouraged to book as soon as possible, contacting directly the selected hotel.

5 STARS HOTELS

- *PATRIA PALACE HOTEL (5 stars)*

Location: Piazzetta Riccardi 13 – Lecce

Walking distance: about 600 meters

Contacts: Tel: (+39) 0832 245111; Fax: +39 0832 245002

Web site: click here

Mail: info@patriapalacelecce.com

Agreement: In order to avail of the agreement, you must specify the reason of the stay **(Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento)** when you are booking the room

Room prices (Breakfast included):

- Single room € 90,00
- Twin/Double room € 130,00

- *RISORGIMENTO RESORT (5 stars)*

Location: Via Augusto Imperatore, 19 - Lecce

Walking distance: about 700 meters

Contacts: Tel: (+39) 0832 246311; Fax: +39 0832 245976

Web site: click here

Mail: info@risorgimentoresort.it

Agreement: In order to avail of the agreement, you must specify the reason of the stay (**Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento)** when you are booking the room

Room prices (Breakfast included):

- Single room “Standard” € 110,00
- Double room “Superior” € 140,00
- DUS “Deluxe” € 120,00
- Double room “Deluxe” € 150,00
- DUS “Executive” € 150,00
- Double room “Executive” € 160,00

- *GRAND HOTEL TIZIANO E DEI CONGRESSI (4 stars)*

Location: Viale Porta d'Europa - Lecce

Walking distance: about 600 meters

Contacts: Tel: (+39) 0832 272111; Fax: +39 0832 272841

Web site: click here

Mail: info@grandhoteltiziano.it

Agreement: In order to avail of the agreement, reservation must be made by written request, email or fax, referring to the conference organized by the University of Salento (19-20-21 May) and by providing the data of a credit card to guarantee the room reservation.

Room prices (Breakfast included):

- Single room € 55,00
- DUS "Standard" € 65,00
- Twin/Double room "Standard" € 75,00
- DUS "Superior" € 85,00
- Twin/Double room "Superior" € 105,00

- *SUITE HOTEL SANTA CHIARA (4 stars)*

Location: Via Degli Ammirati, 24 - Lecce

Walking distance: about 750 meters

Contacts: Tel: (+39) 0832 304998; Fax: +39 0832 304998

Web site: click here

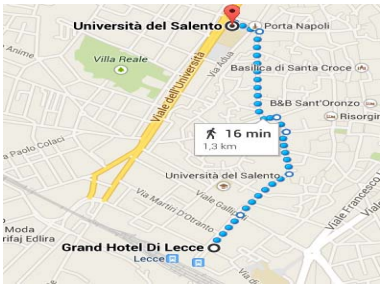
Mail: info@santachiaradilecce.it

Agreement: In order to avail of the agreement, reservation must be made by written request, e-mail or fax, referring to the conference organized by the University of Salento (**Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento**) and by providing the data of a credit card to guarantee the room reservation.

Room prices (Breakfast included):

- DUS "Classic" € 70,00
- DUS "Superior" € 80,00
- Twin/Double room "Classic" € 110,00
- Twin/Double room "Superior" € 120,00

- ***GRAND HOTEL DI LECCE (4 stars)***



Location: Via Oronzo Quarta, 28 - Lecce

Walking distance: about 1700 meters

Contacts: Tel: (+39) 0832 309405

Web site: click here

Mail: info@grandhoteldilecce.it

Agreement: In order to avail of the agreement, you must specify the reason of the stay (**Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento)** when you are booking the room

Room prices (Breakfast included):

- Single room € 59,00
- DUS € 63,00
- Double room € 75,00
- Double room "De luxe" € 98,00
- Suite € 105,00

- ***HILTON GARDEN INN LECCE (4 stars)***

Location: Via Cosimo De Giorgi, 62- Lecce

Walking distance: about 1700 meters

Contacts: Tel: (+39) 0832 5252; Fax: +39 0832 525888

Web site: click here

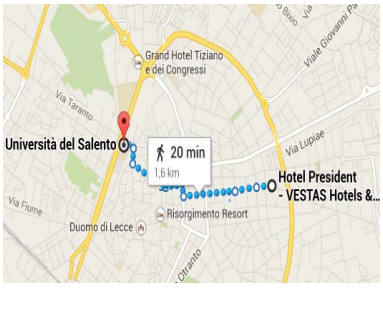
Mail: info@hgilecce.it

Agreement: you must refer to the Unisalento agreement when you are booking the room

Room prices (Breakfast included):

	SINGLE ROOM	DUS	DOUBLE ROOM
Standard room	€ 77,00	€ 82,00	€ 102,00
Deluxe room	€ 97,00	€ 97,00	€ 117,00
Superior room	€ 107,00	€ 107,00	€ 127,00
Junior Suite room	€ 127, 00	€ 127,00	€ 147,00

- ***HOTEL PRESIDENT LECCE (4 stars)***



Location: Via Salandra, 6 - Lecce

Walking distance: about 1700 meters

Contacts: Tel: (+39) 0832 456111; Fax: +39 0832 456632

Web site: click here

Mail: info@hotelpresidentlecce.it

Agreement: In order to avail of the agreement, you must specify the reason of the stay (**Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento)** when you are booking the room

Room prices (Breakfast included):

- Single room "Standard" € 55,00
- DUS "Superior" € 60,00
- DUS "Deluxe" € 70,00
- Double room "Superior" € 80,00
- Double room "Deluxe" € 90,00

3 STARS HOTELS

- *EOS HOTEL LECCE (3 stars)*

Location: Via Vittorio Alfieri, 11 - Lecce

Walking distance: about 2000 meters

Contacts: Tel: (+39) 0832 230030; Fax: +39 0832 347840

Web site: click here

Mail: info@eoshotel.it

Agreement: In order to avail of the agreement, you must specify the reason of the stay (**Next Generation Design Guidelines for Composites in Construction – General Meeting organized by the University of Salento)** when you are booking the room

Room prices (Breakfast included):

- DUS "Standard" € 60,00
- DUS "Superior" € 65,00
- Double room "Standard" € 80,00
- Double room "Superior" € 90,00

http://www.tu1207.eu

ESF provides the COST Office through a European Commission contract

COST is supported by the EU Framework Programme

EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY